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The Role of Artificial Intelligence in Developing Humanities Studies from Archaeological Discovery to Historical Recording and Geographical Analysis: Application Models

Lecturer Sajjad H. Alwan[1], Samar Abbas Abdulkareem[2], Suha Salah Tawfeeq[3], Zainab Abdulrazaq Khalaf Habib[4], Fatima Ali Mohammed[5], Hawraa Abdul Ameer Hussein Ali[6], Aya Rafid Mahdi[7]

Abstract

The Fourth Industrial Revolution represents an advanced stage of technological development, characterized by the integration of digital, physical, and biological technologies, with a strong focus on smart connectivity and advanced data analysis. At the core of this revolution stands Artificial Intelligence (AI), which enables the processing of vast amounts of data, decision-making with speed and accuracy, automation of processes, and enhancement of productivity and quality. This research examines the transformative role of AI in the humanities, particularly in archaeological, historical, and geographical studies, where traditional methods face limitations in handling complex and extensive datasets.The study aims to highlight these limitations, explore the potential of AI in analyzing diverse archaeological data to uncover new patterns, examine its role in processing large historical sources, and investigate its application in spatial data analysis for environmental and urban changes. The main hypothesis posits that AI can reveal patterns and insights unattainable by conventional methods, thereby enhancing understanding of past civilizations, historical trends, and geographical dynamics.Using a descriptive-analytical methodology supported by practical examples, the research illustrates AI applications such as satellite image analysis, artifact examination, and archival data processing. The findings indicate that integrating AI with humanities research not only improves data analysis efficiency but also maintains the critical and interpretive framework of the humanities, enabling a deeper understanding of society, history, and collective awareness in the digital era.The study concluded that integrating artificial intelligence into humanities research not only improves the efficiency and speed of data analysis but also contributes to the development of the research methodology itself, by shifting from descriptive to analytical and predictive studies, while preserving the critical and interpretive dimensions of the humanities. The study also recommends strengthening collaboration between researchers in the humanities and computer science, establishing open-source Arabic digital archives, and training researchers in the use of artificial intelligence tools. This will contribute to broadening the horizons of humanities research and connecting the past with the present within an integrated scientific framework that meets the demands of the digital age.

Introduction

The Fourth Industrial Revolution represents an advanced stage of technological development, distinguished from previous stages by the integration of digital, physical, and biological technologies,

[1] Translation Department, College of Arts, University of Baghdad, Iraq. sajad.hasan1106@coart.uobaghdad.edu.iq, https://orcid.org/0009-0001-0936-2302., (Corresponding Author)
[2] Department of Archaeology, College of Arts, University of Baghdad, Iraq. summer.abbas@coart.uobaghdad.edu.iq.
[3] Department of History, College of Arts, University of Baghdad, Iraq. suha.s@coart.uobaghdad.edu.iq

[4] Department of History, College of Arts, University of Baghdad, Iraq. zainab.a@coart.uobaghdad.edu.iq

[5] Department of Geography and Geographic Information Systems, College of Arts, University of Baghdad, Iraq. fatma.ali1207b@coart.uobaghdad.edu.iq

[6] Department of History, College of Arts, University of Baghdad, Iraq. Hawra.A@coart.uobaghdad.edu.iq

[7] Department of Geography and Geographic Information Systems, College of Arts, University of Baghdad, Iraq. aya.rafed1207b@coart.uobaghdad.edu.iq

with a strong focus on smart connectivity and advanced data analytics. Artificial intelligence (AI) stands at the core of this revolution as a tool capable of analyzing massive amounts of data, making decisions quickly and accurately, automating processes, reducing human error, and enhancing productivity and quality.

As a result of this revolution and emerging technologies, the world has witnessed in recent years an unprecedented scientific transformation that has profoundly affected all fields. Today, it is rare to find a domain or sector that has not been influenced by AI and its applications, including education and research in the humanities. AI has provided researchers and learners with broader horizons for understanding history, culture, and society, and for analyzing geographical phenomena with greater precision. It has also enabled the extraction of patterns and correlations that are difficult to detect using traditional methods, opening new avenues for the humanities to gain a deeper and more comprehensive understanding of the past and present. At the same time, this transformation requires ethical awareness and specialized training to ensure the responsible use of these technologies while maintaining the critical role of the humanities in preserving the reflective dimension of human experience.

Thus, it can be argued that the Fourth Industrial Revolution and AI have become advanced technical tools for developing education and research. However, the humanities remain central to understanding society, history, and collective consciousness. AI provides fast and precise tools for analyzing academic data, while the humanities offer an interpretive framework for understanding meanings and contextualizing results historically and culturally. This integration ensures that education is not limited to technical skills but also encompasses an understanding of social and political dynamics, thereby enhancing collective awareness and enabling individuals to make more responsible decisions in the era of digital transformation.

The study aims to emphasize the importance of integrating modern technical tools with the humanities, thereby enhancing the quality of scientific research and preserving the critical and interpretive role of these disciplines in understanding society, history, and collective consciousness. It also seeks to highlight the shortcomings of traditional methods used in processing data within archaeological, historical, and geographical studies, and to underline the need for more advanced tools and technologies to handle the vast and complex amounts of information. Moreover, the research explores the potential of AI in analyzing diverse archaeological data, contributing to the discovery of new patterns, a deeper understanding of ancient civilizations, and the analysis of extensive historical sources to extract key trends and ideas that link the past with the present. Additionally, it aims to demonstrate how AI techniques can be employed to process spatial data and digital maps to monitor environmental and urban changes with accuracy and efficiency surpassing traditional methods.

From the research objectives emerges the study problem, which revolves around the limitations faced by the humanities in processing vast and complex datasets using traditional methods. These limitations raise the question of how Fourth Industrial Revolution technologies, particularly AI, can overcome these constraints and provide more precise and effective tools for supporting scientific research in the humanities, especially in archaeological, historical, and geographical studies. This problem is structured around three central questions:

1. How can AI contribute to processing diverse archaeological data (texts, images, inscriptions, and material artifacts) to uncover new patterns and correlations that enhance the understanding of ancient civilizations?
2. How can AI assist in analyzing extensive historical sources (manuscripts, documents, archives) to extract key trends and ideas that contribute to a deeper understanding of the past and its connection to the present?
3. How can AI techniques analyze spatial data and digital maps to monitor environmental and urban changes with precision surpassing traditional methods?

To address the stated problem and answer the study questions regarding AI's role in advancing historical, geographical, and archaeological studies, the research assumes that AI is capable of revealing new patterns and correlations in archaeological material that are not possible using traditional methods, thereby assisting in reconstructing a clearer picture of ancient civilizations. In the historical domain, AI technologies are expected to facilitate the analysis of manuscripts, documents, and extensive archives, enabling the extraction of intellectual and political trends and linking them to contemporary contexts. In geography, the hypothesis posits that employing AI techniques in analyzing

spatial data and satellite imagery will allow monitoring of environmental and urban changes with a level of accuracy and speed beyond what is achievable with traditional methods.

Thus, the overarching hypothesis of the research asserts that the integration of AI and the humanities is not limited to technical aspects alone but also achieves a necessary balance between quantitative data analysis and critical, interpretive understanding, enhancing the quality of scientific research and reinforcing its role in building collective awareness.

Given the nature of the study, a descriptive-analytical methodology was employed to collect data on the use of AI in archaeological discovery, historical documentation, and the analysis of geographical phenomena. The data were then systematically described using practical examples that illustrate the application of AI in archaeological, historical, and geographical studies. For instance, the study examined the use of AI techniques in processing satellite imagery to detect environmental and urban changes in geographical studies, analyzing inscriptions and archaeological artifacts to reconstruct perceptions of ancient civilizations, and employing machine learning algorithms to analyze historical documents and manuscripts to extract patterns and intellectual or political trends. This methodology combines descriptive approaches, which identify the characteristics of the studied phenomenon, with analytical approaches that interpret the results and link them to the research questions, supported by practical applications that make the findings relevant and applicable to the needs of scientific research in archaeology, history, and geography.

Artificial Intelligence and Archaeological Discovery

Cultural heritage, according to the 1954 Hague Convention under the auspices of UNESCO, is considered property of major importance to the heritage of peoples and includes all tangible elements with historical, artistic, scientific, or cultural value. This encompasses real estate and lands containing buildings or archaeological, architectural, or historical sites, museum collections, libraries, and scientific collections, as well as historical and archaeological sites and artifacts that testify to past civilizations and must be protected from destruction or looting during armed conflicts (UNESCO, 1954). This convention underscores the importance of studying archaeology, as it contributes to enhancing the understanding of human history, reconstructing accurate images of ancient societies, and connecting the past with the present through the analysis of tools, manuscripts, and buildings. By studying buildings, inscriptions, tools, and manuscripts, researchers can infer patterns of life, social and political structures, and economic and cultural beliefs. Archaeology also helps fill gaps left by written sources, track cultural and technological developments, and understand human interaction with the environment.

Moreover, archaeology strengthens national identity and citizenship by enabling individuals to recognize their historical roots and comprehend shared heritage, reinforcing their sense of belonging to society and the nation and fostering appreciation for its cultural and civilizational values over time. Archaeology also represents an important economic resource. For example, in 2021, Egypt earned approximately $4.9 billion from tourism at archaeological sites, which increased to $13.6 billion the following year due to heightened governmental attention to showcasing Egypt's ancient civilization and preserving its monuments (Basima Mohamed Hamed Ibrahim, 2024, p. 365).

Due to this importance, archaeology and excavation practices have evolved through multiple stages until their integration with artificial intelligence (AI). Initially, archaeological excavations were conducted randomly in search of treasures and valuable artifacts. In the modern era, new techniques and methods emerged for excavation and scientific analysis, including aerial photography, remote sensing, and satellite imaging, along with interdisciplinary collaboration among archaeologists, geologists, chemists, physicists, and computer scientists. This collaboration has led to more advanced techniques such as genetic analysis, 3D imaging, and computational modeling (Mahmoud Hamed Elhosary, 2024, p. 26).

Given the significance of archaeological heritage, the scientific advancements across multiple fields, and challenges faced by archaeologists—such as vast areas to explore, the fragile nature of artifacts, and the limitations and time demands of traditional methods—the use of modern AI-enhanced technologies in archaeology becomes essential. By the late twentieth century, advances in data analysis allowed archaeologists to employ machine learning and data mining techniques to predict archaeological sites based on historical and geographical data patterns. These developments highlight the importance of integrating AI with archaeology for excavation, mapping archaeological sites, digital restoration, and 3D modeling of artifacts, among other applications (Abirami Veena, 2024).

The potential applications of AI in archaeology are vast, as new scientific techniques and discoveries emerge continuously. AI can be employed to preserve and protect artifacts due to its strong predictive capabilities when analyzing and recording archaeological data. Drones can extend aerial photography for archaeological sites, document sites, and capture detailed images for subsequent analysis. LiDAR-equipped drones can detect hidden archaeological features obscured by vegetation or soil. These technologies are highly effective for excavating previously inaccessible areas, allowing archaeologists to document sites and analyze extracted geographical data with high accuracy and lower costs (Mahmoud Hamed Elhosary, 2024, p. 34).

Archaeologists have integrated Geographic Information Systems (GIS) with AI (AI-GIS) to analyze maps and spatial data to identify previously undiscovered sites and monitor environmental changes affecting the stability of ancient civilizations. For example, in 2015, American archaeologist Sarah Parcak predicted approximately 50 new burial sites along the Nile, particularly areas affected by looting and clandestine excavations following the 2011 revolution, such as the Lisht archaeological area, the capital of Egypt in the Middle Kingdom (Parcak, 2015). This led the Egyptian government to collaborate with Parcak and other American researchers to develop a national satellite imaging project to monitor and protect archaeological sites from looting, illegal construction, and other threats (Pringle, 2011).

European universities, in collaboration with the Hellenic Institute of Archaeological Research, launched the Peloponnesus Project in Greece, employing AI and GIS to study the historical and environmental development of the Peloponnese region. Through the analysis of spatial and temporal changes in ancient population and agricultural patterns, they examined the impact of climate and environmental changes on the rise or decline of civilizations, particularly during the Bronze and Iron Ages. In 2019, they discovered a network of buried or naturally covered Roman roads, improving understanding of trade and communication in Roman-era Peloponnese (Jim Newhard et al., 2025).

Archaeologists have also utilized CNNs trained on high-resolution satellite imagery (Landsat, WorldView) to identify recurring patterns such as buildings, roads, farms, or buried ancient structures. Scott Branting from the University of Central Florida, leading a U.S. Department of State project in collaboration with ASOR, tracked damage to cultural heritage sites in war-torn Syria and northern Iraq, documenting hundreds of threatened sites and creating databases of approximately 6,000 lesser-known sites in each region. Many of these sites were previously unknown or unexplored, providing significant post-conflict research opportunities (Schlueb, 2017; Jesse Casana & Elise Jakoby Laugier, 2017).

LiDAR (Light Detection and Ranging) technology, which sends light pulses to the ground and measures their return time to create highly accurate 3D terrain models, has revolutionized archaeological surveying. Airborne LiDAR has allowed archaeologists to explore vast areas previously inaccessible due to dense forests or rugged terrain. Between 2016–2020, LiDAR enabled the discovery of ancient cities and roads hidden under vegetation in Cambodia through the Angkor Archaeological LiDAR Project, led by Damian Evans in collaboration with the National Authority for Angkor Protection, the French School of the Far East, and the University of Sydney. This project distinguished natural terrain from human-made patterns, revealing integrated urban networks, irrigation systems, and previously unknown pre-Angkorian cities, transforming historical understanding of Khmer civilization (Damian H. Evans et al., 2013; European Commission, 2020).

The same LiDAR technology was applied by PACUNAM in Guatemala, surveying approximately 2,100 km² in the Maya Biosphere Reserve (Petén), revealing hidden Mayan structures, elevated roads connecting cities, agricultural systems, and a broader urban distribution than previously known (Clynes, 2018).

Artificial Intelligence and Reading and Recording History

The ongoing digital revolution has made artificial intelligence (AI) a tool capable of producing, analyzing, and processing historical data at a speed and accuracy surpassing human capabilities. However, the entry of machines into the field of historiography raises philosophical and methodological questions regarding the role of the human historian, the objectivity of narrative, and the credibility of digital memory. Nevertheless, AI's use in historical documentation significantly facilitates processes such as transcription, text analysis, cataloging, and conveying images of the past.

Several historical projects have already relied on AI tools. One prominent example is the Transkribus project (2016), a major European initiative launched under the "Recognition and Enrichment of Archival Documents" program, which aimed to use AI to understand, read, and convert

handwritten historical manuscripts into searchable digital text (Transkribus, 2016). The project employed advanced OCR (Optical Character Recognition) technologies powered by AI and machine learning (ML) to extract texts with high precision. Beyond character recognition, the system interprets document structure and context. Additionally, it uses Handwritten Text Recognition (HTR), an AI-based technique that understands and interprets historical handwritten scripts (others, 2019).

For instance, if a historian has access to a comprehensive historical archive—such as correspondence, notebooks, or records written by a single individual—Transkribus can interpret the handwriting with very high accuracy and convert images into editable, searchable text. This project saves historians significant time and enables the reading of historically important documents, especially those written in old scripts such as Ottoman Turkish or Latin. Its practical applications include reconstructing Austria's National Archives, digitizing thousands of handwritten documents, analyzing British soldiers' letters from World War I at the Imperial War Museum in London, and projects in Norway, the Netherlands, and Germany to decipher church and municipal records (Suphan Kirmizialtin & David Wrisley, 2020) (others, 2019).

In addition to preserving handwritten documents, AI has been employed to move from traditional historical narration to reconstructing historical events and locations using computational models. For example, the Federal School of Applied Arts in Lausanne, in collaboration with Ca' Foscari University in Venice, launched the "Venice Time Machine" project in 2012. This international project aimed to create a multi-dimensional collaborative model of Venice through an open digital archive of the city's cultural heritage using machine learning technologies, covering more than 1,000 years of development. The project tracked the circulation of news, goods, finances, migration, and architectural and artistic patterns to generate massive historical datasets. It is considered the largest database ever created on Venetian documents, and its second phase is ongoing until 2028 (Venice Time Machine, 2012) (A Virtual Time Machine for Venice, 2017).

Another "Time Machine" project officially launched in 2019 under the EU Horizon 2020 initiative involved collaboration among approximately a dozen research institutions, including the Universities of Utrecht, Luxembourg, and Ghent. Its aim was to revitalize European history through the integration of large-scale historical data, linking Europe's past with modern digital infrastructures. The project focuses on digitizing historical documents, analyzing old maps, and creating 4D models of cities such as Paris, Venice, and Amsterdam, while identifying historical individuals through names, families, and recorded activities. According to the official project website, it will impact key European economic sectors, including ICT software, augmented and virtual reality applications, creative industries, and tourism. Additionally, the project will provide new insights for urban planning, land management, and smart city development, with long-term positive effects on European cohesion, the economy, and society, while promoting critical thinking, European identity, scientific and technological competitiveness, entrepreneurship, and employment in knowledge- and creativity-intensive sectors. The project was funded by the European Union's Research and Innovation program in 2020 (Unleashing Big Data of the Past – Europe Builds a Time Machine, 2019) (Time Machine Organisation, 2019).

Artificial Intelligence and the Analysis of Geographical Phenomena

With the rapid advancement of artificial intelligence (AI) technologies, their applications have expanded to encompass various branches of geography, providing unprecedented analytical capabilities. A systematic review of 400,000 geographical studies published between 1990 and 2023 revealed that AI applications accounted for 8.1% of geographical research, with a twentyfold increase in such studies over three decades. Among the various geographical topics, remote sensing and spatial data analysis emerged as the most explored areas using AI, with feature extraction from imagery being the most widespread and impactful application of current AI methods (others C. A., 2026).

This large volume of studies reflects AI's significant contribution to the advancement of geographical research through the analysis of massive spatial datasets. AI enables geographers to process enormous amounts of geographical data derived from satellite imagery, sensors, drones, and Geographic Information Systems (GIS), extracting precise spatial patterns that are difficult for humans to detect using conventional techniques. It also allows geographers to predict natural phenomena such as floods, droughts, storms, climate changes, and the likelihood of earthquakes and landslides, in addition to analyzing environmental changes to monitor desertification, deforestation, pollution levels, and ice melting. This information supports decision-makers in developing appropriate environmental policies. AI is also applied to human geography, including population density, distribution patterns, internal and external migration, transport networks, urban planning, and smart city design. Moreover,

AI enhances GIS by improving the accuracy of digital maps, automating satellite image classification, and accelerating spatial analysis processes (others C. A., 2026).

Geographers have employed AI in remote sensing image analysis using machine learning and deep learning algorithms to identify environmental patterns, land cover, and land-use changes, extracting spatial information with higher precision than traditional methods. These techniques have proven successful in studies monitoring environmental degradation, deforestation, and natural resource management, such as classifying vegetation types or assessing vegetation health using deep convolutional neural networks (CNNs), and detecting temporal land-use changes, including deforestation and urban expansion (others N. K., 2025).

Integrating AI techniques with GIS has proven effective in advancing human geography. Machine learning models combined with GIS perform analytical tasks such as spatial classification, prediction, and enhancement of traditional analysis to detect spatial patterns and forecast environmental or social changes. Geographers have successfully classified and predicted land use in environmental studies and analyzed traffic flows and population movement using location data (Ahmed, 2024). Automated satellite image analysis through deep learning, combining CNN and LSTM networks with GIS, has improved the analysis of multi-dimensional and temporal data, facilitating the monitoring of dynamic environmental changes such as urban expansion and land cover changes, increasing image classification accuracy from 78% to 92% after optimizing parameters with specialized algorithms. Combining LiDAR, SAR, and optical imagery with AI models significantly contributes to producing high-resolution urban maps used in urban planning, infrastructure monitoring, and assessing changes in built and environmental elements (Askari, 2024).

Among the most prominent geographical projects utilizing AI, the World Resources Institute launched the Global Forest Watch platform in 1997 to monitor forest cover changes. By analyzing satellite imagery with AI and machine learning algorithms, the project enabled near-real-time global deforestation monitoring, spatial environmental change tracking, and the production of precise interactive maps. This platform allowed geographers to shift from descriptive monitoring to predicting environmental risk zones by studying forest conditions in Indonesia, Singapore, the Amazon, the Congo, and other regions (Hanson, 2025). Using GLAD Alerts, derived from satellite imagery to indicate areas at risk of deforestation and updated weekly, it was observed that Central Africa experienced an 18% reduction in deforestation, equivalent to approximately 50,000 hectares per year (Shea, 2021). Reports from 2023–2024 indicated a 36% reduction in forest loss in Brazil and 49% in Colombia (Institute, 2024). In Panama, integrating real-time monitoring with field protection measures and resource investment led to an 88% decrease in deforestation between 2022 and 2025 (Taylor, 2025).

Conclusion and Recommendations

It can be concluded that artificial intelligence (AI) has made a substantial contribution to the advancement of the humanities, becoming an effective tool to support research across multiple fields, from archaeological exploration and monitoring historical sites to analyzing historical texts and geographic phenomena. AI enables researchers to process vast amounts of data, uncover hidden patterns and relationships among different elements, thereby enhancing analytical accuracy while saving time and effort compared to traditional methods. In addition, AI contributes to the creation of highly accurate maps of historical sites and regions, and provides predictive models to understand the development of civilizations, expanding the scope of humanities research and linking the past with the present in a more comprehensive and objective manner.

AI has brought a transformative change to archaeology, making it faster, more precise, and more efficient in handling diverse archaeological data, whether texts, images, inscriptions, or physical artifacts. It enables archaeologists to analyze vast quantities of archaeological information quickly and efficiently, detect new patterns and correlations among different elements—such as natural terrain, ancient buildings, or roads—and relate archaeological sites to their surrounding environment and water resources, thereby inferring the social, political, and cultural structures of ancient civilizations. The findings indicate that integrating AI with technologies such as LiDAR and Geographic Information Systems (GIS) has led to the discovery of previously hidden sites beneath dense forests or complex terrains, enabled virtual reconstruction of cities, and improved both efficiency and objectivity in archaeological analysis. AI has also contributed to producing accurate maps of archaeological sites, predicting unexplored areas, and preserving cultural heritage, thereby enhancing our understanding of the past and connecting it to the present, while allowing researchers to explore human history comprehensively. As AI continues to evolve, its potential to reveal more about our ancient civilizations

remains virtually limitless, establishing it as a key tool for deepening our understanding of cultural heritage and advancing archaeology to meet contemporary demands.

The study also confirmed that integrating AI into geographic studies has transformed the field from descriptive research into predictive analytical research, enhancing both the accuracy and speed of spatial decision-making, particularly in the context of big data. AI's impact extends beyond improving technical tools used in geography; it reshapes the entire geographic research methodology by transitioning from spatial description to deep predictive analysis, thereby improving human understanding of the environment and our relationship with it.

Recommendations

1. Enhance collaboration between computer scientists and researchers in the humanities: Such collaboration is essential to fully utilize advanced AI applications, including the analysis of satellite imagery to detect buried archaeological sites, digital history documentation through the analysis of massive historical texts, and the analysis of geographic phenomena. These areas require specialized technical expertise beyond the capacity of individual humanities researchers. Collaboration transforms AI from an isolated technical tool into an integrated research instrument capable of generating new insights into the past and providing deeper analysis of geographic spaces and associated social phenomena.
2. Establish open-access digital archives in Arabic: This strategic step is crucial for strengthening the presence of humanities research in the AI era. The absence of structured Arabic datasets limits the potential of AI to analyze historical documents, manuscripts, old maps, and geographic records. Open archives allow the training of AI models capable of reading Arabic texts and linking them to spatial and temporal contexts, thereby advancing digital history, analyzing geographic and archaeological transformations in the Arab world, and providing researchers with effective tools to reconstruct the past using modern scientific methodologies.
3. Train researchers in using AI tools for academic research: Training is essential to keep pace with contemporary methodological transformations, enabling humanities researchers to utilize important tools such as text analysis, smart GIS, and archaeological image analysis. This opens new horizons for studying history, archaeology, and human geography. It facilitates the shift from traditional descriptive research to analytical and predictive research, enhancing the ability of humanities research to interpret complex phenomena and connect historical events with their spatial and environmental contexts within an integrated scientific framework.
4. Implementing these recommendations directly strengthens the role of AI in advancing the humanities by linking modern technology with historical, geographic, and archaeological research methodologies. Consequently, AI becomes a tool for reinterpreting the past, analyzing the present, and anticipating the future through practical models ranging from archaeological exploration to digital history documentation and geographic phenomenon analysis.

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