

AI Role in Identifying Archaeological Sites and Uncovering Artifacts

دور الذكاء الاصطناعي في تحديد المواقع الأثرية والكشف عن الآثار

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Abstract:

The world has witnessed a major revolution in artificial intelligence (AI) and scientific research in recent years. This impact has been evident in most areas of life, where AI applications have become essential and indispensable in various fields, such as medicine, engineering, space sciences, and others. The use of AI technologies in archaeological discovery and excavation has also had its unique mark and character, enabling scientists and researchers to analyze large amounts of data and extract important information. It also played a crucial role in identifying archaeological sites and uncovering artifacts. AI programs trained in recognition and prediction are used to identify archaeological sites locations and artifacts types found there through processing large amounts of data quickly and detecting patterns and links that may be difficult for humans to identify and see. Therefore, AI is particularly useful in analyzing aerial imagery and remote sensing to identify distinctive elements and clues necessary for recognizing potential archaeological sites, especially in areas difficult to access or experiencing conflict. AI can also analyze historical and geographical data to accurately estimate underwater or invisible sites. Additionally, it can help protect archaeological sites by predicting the impact of environmental changes and taking preventive measures. However, AI cannot be a substitute for the human factor, in this case, archaeologists. AI's role is to enhance archaeologists' capabilities and not replace them. AI technology is a powerful tool for scientists, but it cannot in any way replace scientists' knowledge, experience, and human vision they provide.

Keywords: artificial intelligence, archaeology, remote sensing, archaeological survey, modern technology, archaeological excavations.

المخلص:

لقد شهد العالم أجمع خلال الفترة الماضية ثورة كبيرة في مجال الذكاء الاصطناعي (AI) والبحث العلمي، وظهر تأثير هذا بوضوح على معظم المجالات الحياتية، حيث أصبح توظيف تطبيقات الذكاء الاصطناعي في العديد من المجالات أمراً ضرورياً لا يمكن الاستغناء عنه مثل مجال الطب والهندسة وعلوم الفضاء وغيرها من المجالات الأخرى، وبالنسبة لاستخدام تقنيات الذكاء الاصطناعي في الكشف والتنقيب عن الآثار فقد كان له بصمته وطابعه الخاص، حيث أمكن للذكاء الاصطناعي مساعدة العلماء والباحثين على تحليل البيانات الكبيرة واستخراج المعلومات المهمة، فالذكاء الاصطناعي يلعب دوراً حاسماً في تحديد المواقع الأثرية والكشف عن الآثار. وتستخدم برامج الذكاء الاصطناعي المدربة في التعرف والتنقيب بمكان وجود المواقع الأثرية وأنواع الآثار الموجودة بها وذلك من خلال معالجة كميات كبيرة من البيانات بسرعة واكتشاف أنماط وروابط قد تكون صعبة للبشر تحديدها

ورؤيتها. ولهذا فيصبح الذكاء الاصطناعي مفيداً بشكل خاص في تحليل الصور الجوية والاستشعار عن بُعد لتحديد العناصر المميزة والتلميحات الضرورية لتحديد المواقع الأثرية المحتملة، خاصة في المناطق التي يصعب الوصول إليها أو المناطق التي تشهد نزاعات. كما يمكن للذكاء الاصطناعي تحليل البيانات التاريخية والجغرافية لتوفير تقديرات دقيقة لمواقع تحت الماء أو غير المرئية، بالإضافة إلى ذلك يمكن للذكاء الاصطناعي المساعدة في حماية المواقع الأثرية من خلال توقع تأثير التغيرات البيئية واتخاذ تدابير وقائية. ومع كل هذا فإنه لا يمكن أن يكون استخدام الذكاء الاصطناعي بديلاً للعلماء في مجال علوم الآثار، حيث أن الدور الذي يقوم به الذكاء الاصطناعي هو تعزيز قدرات علماء الآثار وليس استبدالهم، حيث تعمل تكنولوجيا الذكاء الاصطناعي كأداة مساعدة قوية للعلماء، ولكنها لا تستطيع بأي حال من الأحوال استبدال المعرفة والخبرة والرؤية البشرية التي يقدمها العلماء.

الكلمات الدالة: الذكاء الاصطناعي، علم الآثار، الاستشعار عن بُعد، المسح الأثري، التكنولوجيا الحديثة، التقنيات الأثرية.

Introduction:

In recent years, the world has witnessed an unprecedented transformative revolution in the world of artificial intelligence (AI), which has undoubtedly shown a profound impact on a wide range of fields that constitute human existence. Today, it is rare to find a field or sector that has not been affected by AI or its applications. This revolutionary form of intelligence has effectively and irreversibly reshaped and restructured the fabric and essence of our modern lives, leaving no door unopened in its relentless pursuit of progress and innovation. There is no doubt that in the coming years, artificial intelligence will drive progress, growth, and prosperity in many fields.

Archaeology and archaeological excavations evolved through tremendous stages until they integrated with artificial intelligence technologies. At first, artifact discovery and archaeological exploration of heritage sites were carried out separately and randomly, with the primary focus being the collection and discovery of precious treasures and collectibles, distinct from comprehensive scientific study. During the Middle Ages, antiquities were viewed with religious or symbolic significance rather than with actual scientific value and were often used to support religious and historical myths. The European Renaissance saw a growing interest in studying antiquities scientifically, leading to the establishment of academic institutions and universities dedicated to research in this field. The modern age witnessed the development of new techniques and methods used in antiquities excavation and scientific analysis. Techniques such as aerial photography, remote sensing, and satellite imaging have been used to monitor and document archaeological and heritage sites. This era also saw increased collaboration between archaeologists and specialists in geology, chemistry, physics, and computer science. This cooperation has intertwined with the use of advanced technologies such as genetic analysis, 3D imaging, and computer modeling to understand and interpret antiquities. The field of archaeology stands to gain even more from modern technological advancements, leading to improved archaeological discoveries and analyses.

Section 1: Archaeology Definition, History, and Fields

Archaeology is a vital scientific discipline that studies the physical remains of past human societies and ancient civilizations. These remains offer a window into their cultures and histories, providing a comprehensive understanding of the past. Archaeologists and experts can study the remnants of our human ancestors dating back millions of years.¹ The term "archaeology" has Greek origins. It's derived from two words: «archaeo-» (αρχαῖος), meaning «ancient,» and «-logy» (λόγος), meaning "discourse" or "study," literally translated, it means "the study of ancient things." Archaeology focuses on material remains left behind by humans, specifically from the period when humans began crafting tools. Therefore, it's also known as "the science of antiquities" (referencing extinct tribes like Ad) or «the scientific study of ancient people's remains and life».²

Archaeology is a scientific discipline that systematically analyzes the physical remains of human civilizations. In essence, it's a scientific effort to preserve the historical journey of past human societies. Archaeologists achieve this by interpreting and extracting tangible evidence, including cultural heritage, scientific advancements, artistic values, and the intellectual and emotional aspects of these civilizations. This evidence encompasses both written records and physical artifacts, fixed and mobile objects, and creations made by hand or machine. These remains embody the belief systems and artistic expressions of those past eras.³ According to this approach, all human remains left behind can be classified into two main categories: First: Tangible material remains; and Second: Writings and texts. The Arabic term for archaeology stems from the root word "athar." A word that carries various meanings depending on the context and is often used in its plural form with no significant grammatical reason. In general, archaeology in Arabic refers to the physical remains or evidence left behind by past events and civilizations that can take the form of archaeological sites, artifacts displayed in museums, or even intangible aspects like intellectual, cultural, or social values. It particularly focuses on studying ancient civilizations, especially those from the classical Mediterranean period like Greece, Rome, and ancient Egypt. It also encompasses civilizations from the Near East, such as those in Iraq, Iran, and other countries during that era, and extends even further back in time, including artifacts from the Stone Age and other civilizations across Asia and beyond.⁴

The roots of archaeology can be traced back to the Middle Ages in Europe, where a growing interest in antiquities and ancient art emerged. By the fifteenth century, this fascination with the past took on a more scientific character, fueled by a deep admiration for antiquity. Elite Europeans became particularly captivated by ancient artifacts, leading to excavations that unearthed Greek and Roman art and statues, which were then displayed in museums. Archaeology continued to evolve throughout the centuries, undergoing various transformations. By the eighteenth century, it began to break free from many of its earlier constraints. The nineteenth century witnessed significant advancements in excavation techniques, paving the way for archaeology to develop as a distinct field of study. This progress led to the discovery of numerous important archaeological sites.⁵ Furthermore, two main branches of archaeology emerged: prehistoric archaeology, which focuses on the human past before the development of writing systems, and classical archaeology, which deals with the material remains of literate human civilizations.⁶

Archaeology is a branch of the social and human sciences that studies the physical remains of past civilizations and cultures.⁷ Archaeologists rely on various related scientific disciplines to support their research and analysis processes.⁸ Here are some key examples:

- **History:** Archaeology and history have a fundamental, symbiotic relationship that contributes to archaeologists' understanding of the past. Some scholars even consider archaeology to be a specialized branch of history, although a particularly challenging one due to the meticulous attention to detail it requires. However, archaeology goes beyond simply collecting and cataloging ancient artifacts for museums. Archaeologists face the complex task of deciphering the symbolism embedded in these artifacts, essentially interrogating these silent witnesses of the past to extract information and reconstruct history.⁹

- **Geology:** Geology plays a crucial role in helping archaeologists understand the formation of soil and rock layers, which can significantly impact archaeological remains. These geological layers act as a record of past geological and temporal events, providing valuable clues about the age of an archaeological site and the historical events that may have occurred there.¹⁰

- **Analytical Chemistry:** Similar to geology, analytical chemistry assists archaeologists in analyzing the composition and origin of archaeological materials. By understanding the materials' chemical makeup, archaeologists can unveil hidden details and solve mysteries surrounding these silent witnesses of the past.

- **Molecular Biology:** Molecular biology is a modern scientific tool that allows archaeologists to analyze DNA extracted from archaeological remains. This analysis can provide valuable information about the genetic ancestry and lineage of past populations.

- **Computer Science and Information Technology:** Information technology and computer science are revolutionizing archaeology. These disciplines provide tools for analyzing archaeological data, reconstructing three-dimensional objects, and developing virtual models of archaeological sites, offering a deeper and more immersive understanding of the past.

The list of auxiliary sciences employed in archaeology extends beyond these examples. Other relevant fields include physics, anthropology, architecture, geography, and even artistic disciplines like drawing, sculpture, and modeling.

The pursuit of hidden treasures has captivated humanity for millennia. This natural curiosity is a driving force behind archaeological exploration. While archaeology, as a formal discipline, is relatively young, its achievements are nothing short of remarkable. Through intensive research and excavation efforts, archaeologists have unlocked the secrets of past civilizations, shedding light on thousands of years of human history that were once shrouded in mystery.¹¹

The field of archaeological research has expanded to include many different specializations, such as Epigraphy, Architecture, Paleontology, Numismatics, and Archaeological Photography. Many universities and cultural institutions work to support archaeological research and excavations to enrich knowledge about human history and ancient cultures.

Archaeologists always strive to achieve a set of goals by studying ancient remains, including understanding the life of humans by discovering and studying archaeological sites in all parts of the world and tracing their development and spread on the surface of the earth to reconstruct the life and achievements of peoples in the past.¹²

Furthermore, archaeologists regardless of their different disciplines agree to the following objectives of archaeology¹³:

- The study of archaeological sites and their Contents and Temporal and Spatial Context to reconstruct cultural history.
- Reconstruct past human lifestyles by studying how they made their living against the complex background of multiple climates.
- Study the process of culture and explain the causes of why and how human cultures around the world have gone through these different changes and stages.
- Understand archaeological records and all its tools through detailed descriptions of archaeological sites, including buildings, statues, and artifacts discovered.

Human remains at archaeological sites offer a wealth of historical and social information. Scientists studying these remains, through a field known as social archaeology, analyze various elements like pottery, tools, weapons, food remains, buildings, and tombs. By employing modern techniques, they can determine aspects of past societies, such as their economic systems, social structures, religious practices, and customs. Additionally, this analysis helps reconstruct the climatic and environmental conditions of the time. Understanding these ancient societies provides a broader perspective on human history, showcasing cultural and social development over time. This knowledge can also inform our understanding of social and cultural changes in the modern world.¹⁴

Archaeological research and excavation involve searching for and exploring historical and archaeological sites to unearth and study ancient artifacts. Regardless of type or form, these remains are meticulously excavated by archaeologists specializing in uncovering material evidence left by past inhabitants and buried over time. The goal is to gather supplementary evidence that deepens our understanding of specific historical periods. Through this process, archaeologists gain insights into the various activities carried out by past societies within a particular natural and social environment, spanning different historical stages. Therefore, the artistic, aesthetic, and material qualities of artifacts are highly valuable to historians and archaeologists. Studying these archaeological remains, which have become an indispensable resource, allows us to understand and identify the artistic history represented in various forms, such as engraving, sculpture, and drawing, and its significance in the lives of ancient humans.¹⁵

Section 2: Archaeological Survey Methods and Techniques

The term “archaeological survey”¹⁶ refers to the systematic process undertaken by archaeologists to locate and document archaeological sites.¹⁷ This involves a scientific description of the sites without extensive excavation.¹⁸ Archaeological survey utilizes various methods, both traditional and advanced, for discovery. It is one of the most common techniques for finding archaeological sites and remains. Many sites have been discovered through the analysis of maps or historical texts, while others have been unearthed by chance during construction projects. In the past, the focus of archaeological exploration was often on looting, intending to acquire jewelry and treasures.¹⁹

Archaeological surveys play a critical role in archaeological research. They provide invaluable information that guides excavation efforts and increases the likelihood of success. This process involves several key steps: collecting data on the location, size, and condition of archaeological sites. Additionally, archaeologists document the types and quantities of artifacts found at each location. By analyzing this data, they can gain insights into the cultural and historical significance of the sites. Finally, archaeological surveys help identify areas that warrant further investigation or excavation.²⁰

Archaeological surveys are a crucial stage before excavation, as they aid in obtaining satisfactory results and guiding research and excavation efforts. The goal of an archaeological survey is to collect, document, and analyze data to understand past cultures and civilizations. There are various types of archaeological surveys, including aerial, surface, geophysical, geomorphological, marine, stratigraphic, and geological. These techniques are used to identify, document, and preserve archaeological sites.

As a result, archaeological surveys are a vital and sustainable tool for investigating archaeological sites of all types and ages. In fact, it has become essential to conduct a comprehensive archaeological survey before excavating any site.²¹

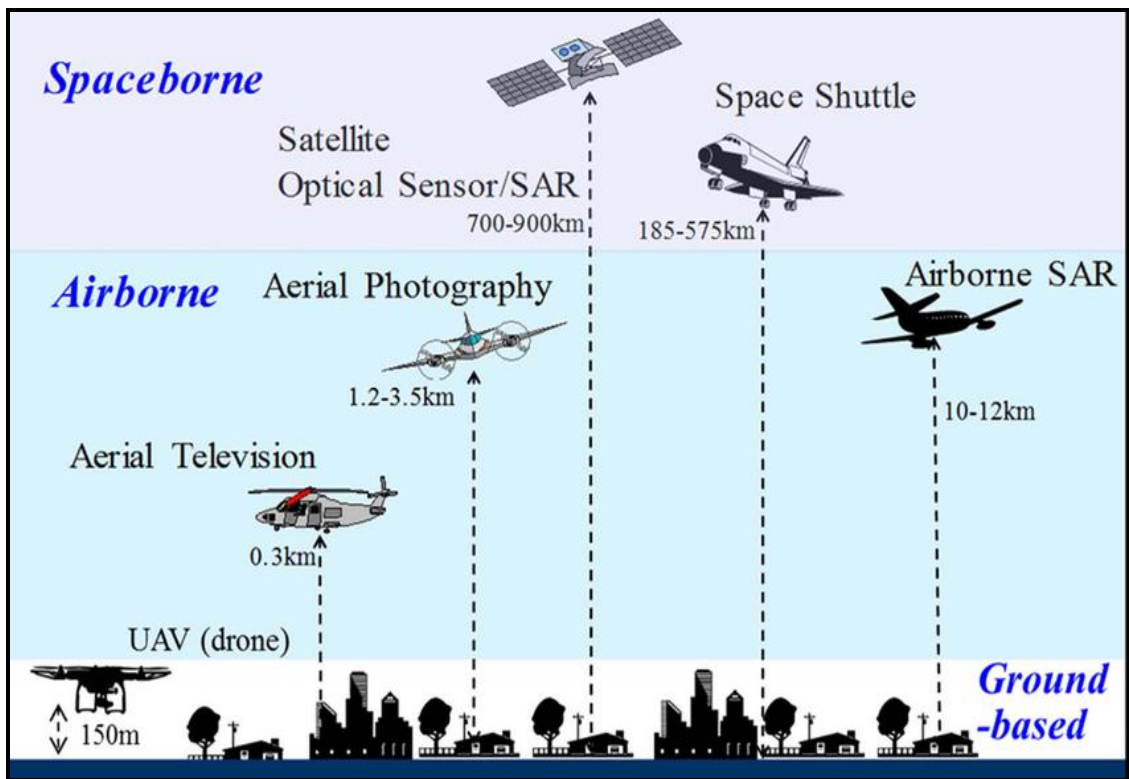
The methodology used for conducting archaeological surveys depends on the specific characteristics of the site. Whether it's an urban sprawl, a rural landscape, a vast desert, or the underwater depths, each environment requires a tailored approach. In urban areas, archaeologists navigate city streets to distinguish between old and modern buildings, as some structures incorporate materials from earlier eras. Conversely, rural, desert, and marine environments often necessitate consulting historical and geographical references. During surveys, encountering remnants like pottery or coins can offer clues about the historical period. Traditionally, archaeologists conducted walking surveys, spreading out at predetermined distances and walking in specific directions, each individual searching for archaeological evidence as they progressed.²² Therefore, archaeological surveys are a targeted effort to locate, document, and understand the various aspects of archaeological sites. This process serves as a valuable tool for scientific and archaeological institutions, allowing them to precisely verify the location of sites before excavation.²³

Archaeological surveys can be categorized into three main types²⁴:

- **Comprehensive:** It's the most thorough but most time-consuming and expensive approach to identify and document all archaeological sites within a designated area using scientific methods of detection.
- **Selective:** It is less costly and time-consuming compared to a comprehensive approach that targets specific locations based on research objectives or existing clues.
- **Rescue:** It is conducted in areas scheduled for major development projects like dam construction or road building to salvage any archaeological remains or sites that may be disturbed or destroyed by the project, meticulously recording all finds to inform future excavation or preservation efforts.²⁵

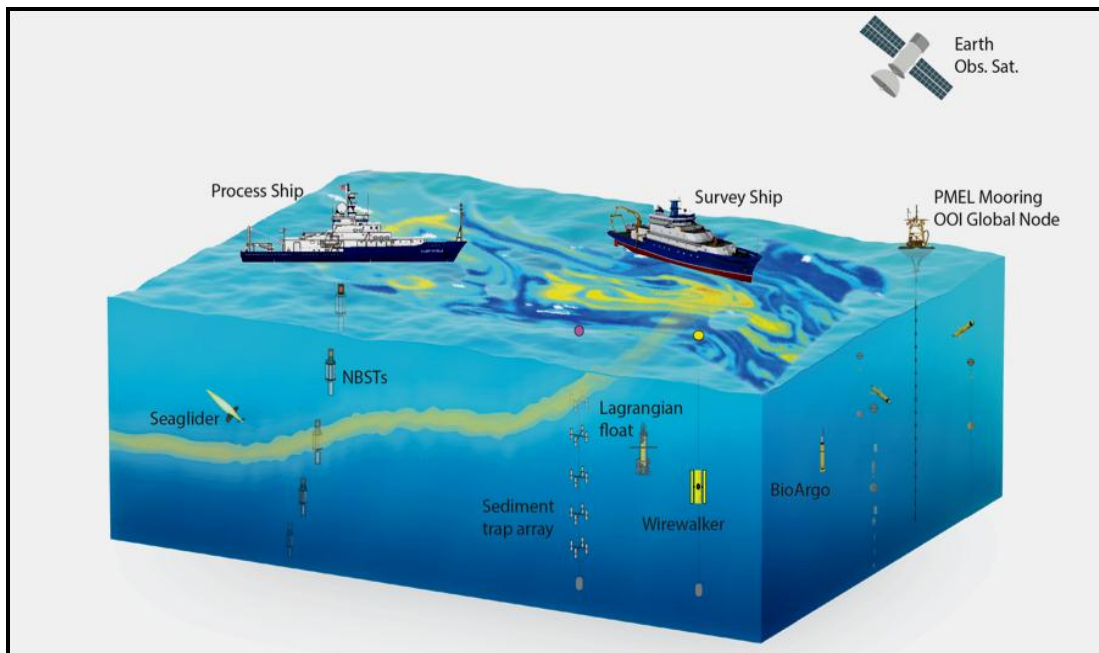
Archaeological surveys employ a variety of methods to locate and characterize archaeological sites and features. These methods can be broadly categorized into three main approaches²⁶:

- **Ground Survey:** Also known as Surface Survey or Walking Survey, is a method used in archaeology that involves direct observation of the land surface for signs and evidence of past human presence and identification of their characteristics and cultural affiliation. It is considered one of the most important archaeological survey methods due to its simplicity and lack of need for special equipment, only requiring sufficient time and appropriate participation from archaeologists, scientists, students, or amateurs.²⁷
- **Internal Survey:** The process of exploring and studying archaeological features and monuments that are located below the ground surface. It utilizes advanced techniques and special tools to identify ancient sites and explore what is below the ground surface with high accuracy and precision. These include chemical analysis of soil samples and geophysical methods which are some of the most important methods and means used to detect antiquities,²⁸ by electrical current, magnetic, and electromagnetic wave (radar).²⁹
- **Aerial Survey:** Utilizes aerial photography and infrared techniques,³⁰ alongside remote sensing technologies employed on aircraft and satellites (Fig. 1). Laser scanning, a recent innovation, has revolutionized archaeological research by providing valuable data for analysis and interpretation.³¹
- **Underwater Scanning:** A technique used to locate and document historical, cultural, and scientific artifacts resting on the seabed of rivers, seas, and oceans. These submerged remains can be shipwrecks, lost cities, or even discarded objects, often deposited due to natural or human factors (Fig. 2).³²



(Fig. 1) Aerial and Satellite Remote Sensing Platforms.

Lindsay, I & Mkrtychyan, A, “Free and Low-Cost Aerial Remote Sensing in Archaeology,” *SAA* 11 (2), (2023): 167.



(Fig. 2) Under Water Survey and Exploration.

(NASA Earth Expeditions) <https://2u.pw/SWIwUS>

Section 3: Artificial Intelligence and Remote Sensing in Archaeology

(A) Use of Artificial Intelligence Technology in Archaeology:

Modern technology plays a crucial role in advancing the field of archaeology. As the saying goes, nothing remains static – technology has revolutionized archaeology, leading to significant discoveries and a decrease in the destruction of archaeological sites, promoting their preservation.³³ Computers have become a cornerstone of archaeological research, aiding in data analysis, modeling,³⁴ and simulation.³⁵ Deep learning and machine learning techniques assist researchers in analyzing vast datasets and extracting valuable information, enabling them to paint a more comprehensive picture of the past. The use of digital methodologies, such as 3D imaging, has become indispensable in archaeological knowledge generation. However, this necessitates a strong theoretical foundation and collaboration across various disciplines.³⁶

Aerial photography, a longstanding remote sensing tool, remains a cornerstone of archaeological research for discovering new sites. It utilizes airplanes, balloons, or satellites. The application of aerial photography in archaeological surveys dates back to the early 20th century. Satellites have also become increasingly important for archaeological site detection.³⁷

The invention of modern communication technologies has revolutionized knowledge sharing and information exchange. Before this, information dissemination relied on traditional methods like pen and paper, or printed books. However, the advent of computers and high-speed internet ushered in a digital revolution across all disciplines.³⁸

Artificial intelligence (AI) has recently gained significant traction in various scientific fields, including archaeology. For archaeologists, AI offers the potential to leverage vast amounts of archaeological data to make informed decisions about the preservation and protection of cultural heritage. AI's powerful predictive capabilities are attracting widespread attention, and archaeologists can now fully exploit this knowledge through AI-powered data analysis.³⁹

The versatility of Drones,⁴⁰ has extended aerial photography to the realm of archaeology. Unmanned Aerial Vehicles (UAVs) are now used to document archaeological sites, capturing detailed reference images for analysis. Airborne laser scanning, employing high-precision laser scanners integrated with UAVs, has proven remarkably effective. This technology can detect archaeological features obscured by trees, vegetation, and soil. These techniques offer a cost-effective and efficient way to generate digital terrain models, enabling the identification of previously unexplored and inaccessible areas using traditional methods. Thanks to this technology, archaeologists can image sites and analyze extracted geographic data with high accuracy at a lower cost.⁴¹

(B) Remote Sensing and Archaeological Discovery:

Remotely sensed data, primarily aerial photographs, satellite images, Airborne Laser Scanning (ALS), and hyper-spectral data, is crucial to our knowledge about the nature and spatial distribution of archaeological sites.⁴² The development of Light Detection and Ranging (LiDAR), has revolutionized archaeological surveys.⁴³

This technology has opened up vast areas for exploration that were previously inaccessible due to dense forests or rugged terrain. LiDAR utilizes laser pulses to measure distances and create highly detailed three-dimensional data sets. There are three main types of LiDAR systems: ground-based, airborne, and spaceborne. Airborne LiDAR is particularly valuable in archaeology, as it can precisely record the Earth's surface, document the area's topography, and even identify objects on the ground with high accuracy.⁴⁴

Modern archaeological methodologies enable the collection of vast amounts of detailed data about archaeological sites. Manual analysis of remote sensing data remains an important and widely used practice in archaeology and heritage management.⁴⁵ However, the ever-increasing volume and quality of remotely sensed data make manual analysis increasingly inefficient. This challenge has spurred the adoption of new technologies in archaeological surveys and exploration.⁴⁶

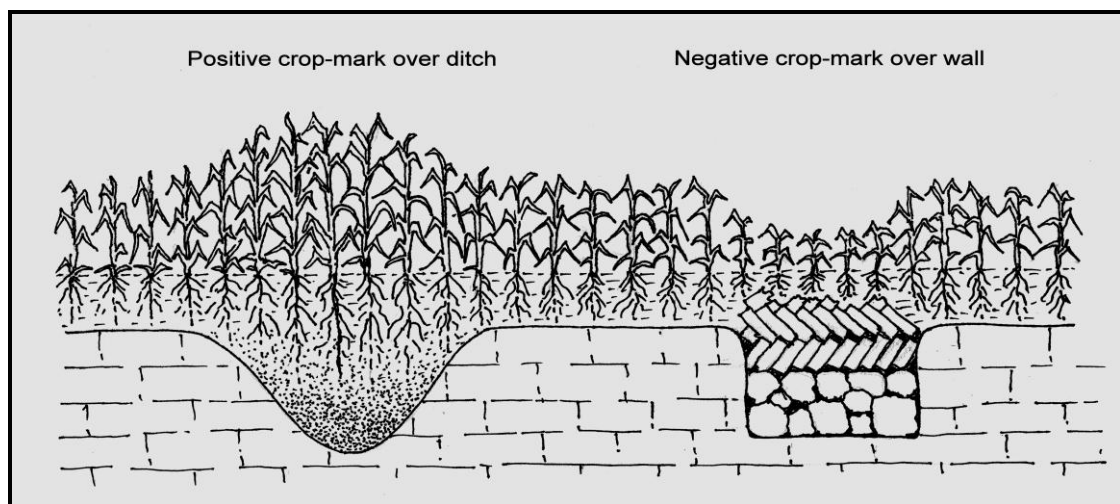
Remote sensing, a product of technological advancement, utilizes computer programs and advanced computing power to analyze and process spatial data collected from space and Earth. This technology has become a valuable tool in archaeology, where traditional methods proved insufficient to understand past settlements fully. Consequently, archaeologists have embraced various auxiliary methods, including remote sensing, alongside artificial intelligence and machine learning.⁴⁷ At its core, remote sensing is the art or science of gleaning information about an object without making physical contact.⁴⁸ It achieves this by capturing images of the Earth's surface and water features from a distance, using electromagnetic radiation reflected or emitted from the Earth across different wavelengths of the spectrum.⁴⁹

Remote sensing signifies acquiring information about an object without physical contact. It involves two crucial steps: using a distant device to collect data and then analyzing that data to understand the object's physical characteristics. These steps are inherently linked. In essence, remote sensing implies a significant spatial separation between the sensor and the object, often by kilometers or hundreds of kilometers.

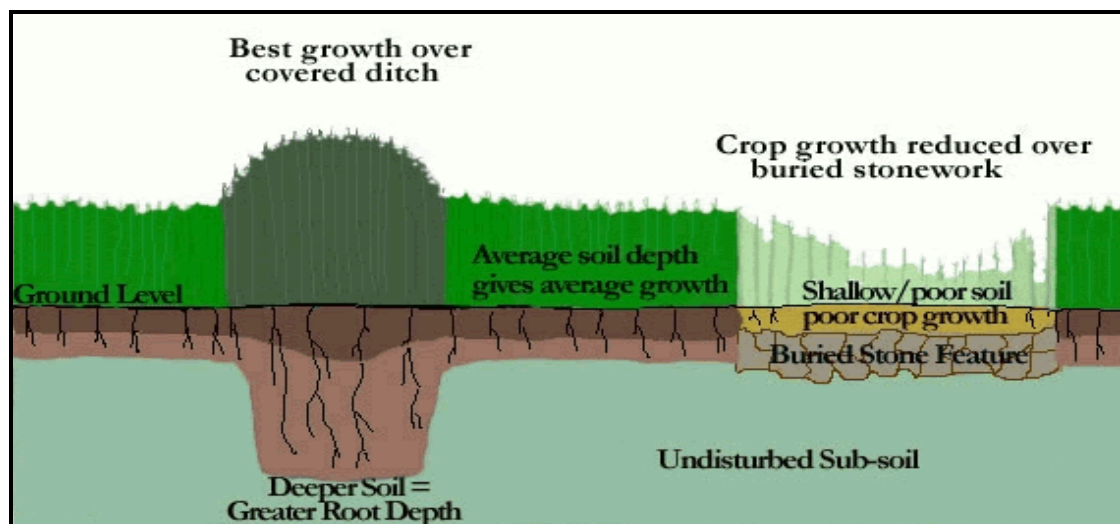
This intervening space is typically filled with air (airborne platforms) or partially with air (space platforms). Consequently, electromagnetic radiation (EM) serves as the essential medium and link between the sensor and the object.⁵⁰

Remote sensing allows for direct detection of archaeological features, whether preserved or extensively eroded, by observing changes in the Earth's surface properties. Even buried features can be indirectly located by analyzing variations in vegetation color and height. These features may appear as visible breaks in the soil or be exposed through agriculture, erosion, or weathering.

Alternatively, they can be inferred from other surface signals, or in buried states, they may manifest as subtle micro-morphological variations (Fig. 3 a,b).⁵¹ The success of remote sensing in archaeology depends on both the timing of data collection and the type of evidence gathered. Four key factors determine data accuracy: spatial resolution, spectral resolution, radiometric resolution, and temporal resolution.⁵² Georeferencing remotely sensed data is a critical intermediate step in archaeological mapping, but it only provides the foundation. Aerial photographs or geophysical/geoelectric maps offer limited insights. Archaeologists collaborate with geophysics and soil science experts to analyze these and measure chemical and physical soil properties.⁵³



(Fig. 3 a) Kent Aerial Photography.



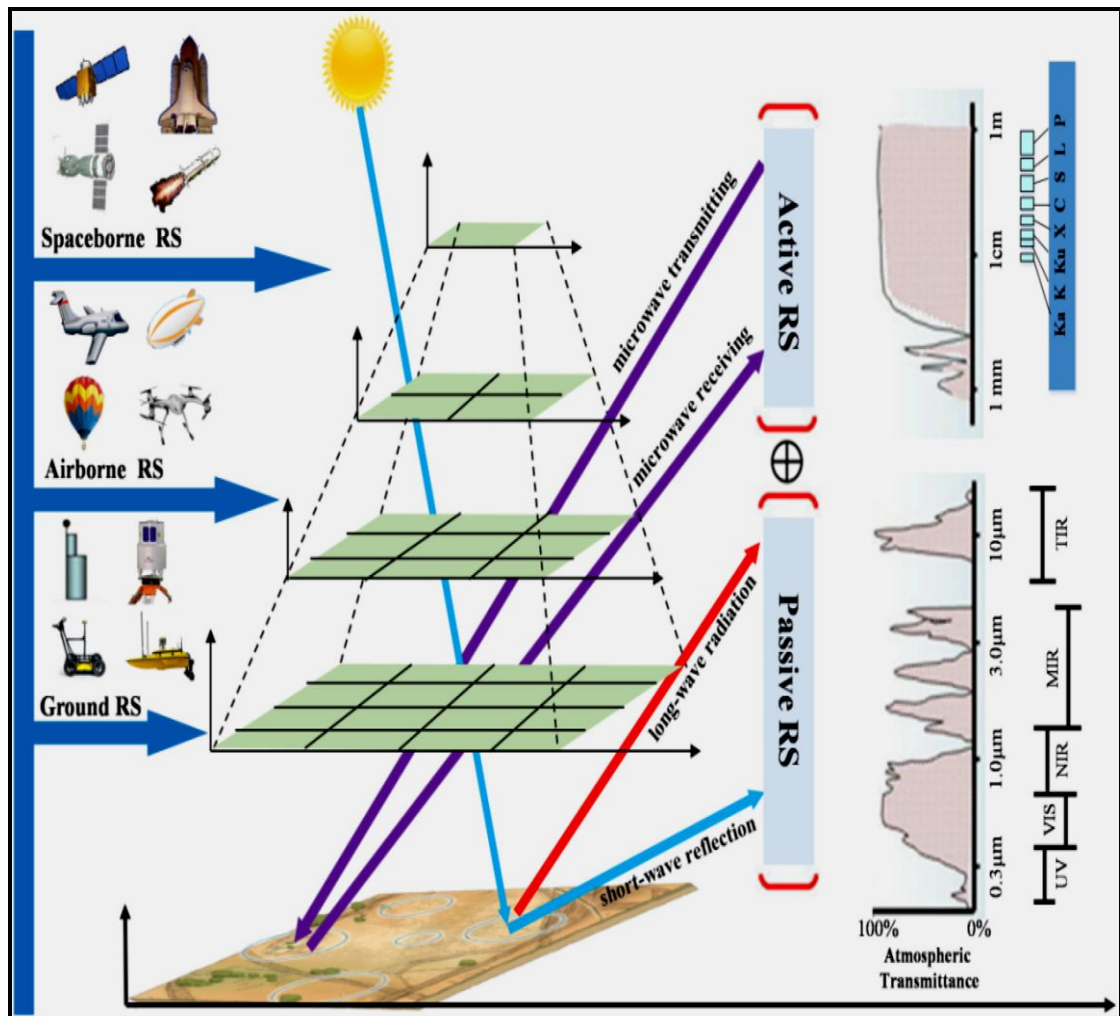
(Fig. 3 b) Field Germination Markers or Crop Mark Site.

The presence of tall plants is an indicator of the existence of an old pit filled with water and moisture below those plants, which stimulates plant growth more than usual. However, if plant growth appears less than normal, it is reasonable to attribute this to the presence of part of an old wall or building foundation below it, which hinders the extension of its roots and its ability to grow.

<https://lochbrowlandscapeproject.wordpress.com/techniques/cropmark-analysis/>

Interestingly, remote sensing techniques weren't developed for archaeology. They originated for military and space applications. However, advancements have made them ideal tools for archaeologists. For example, aerial photographs captured from aircraft or satellites leverage remote sensing technology to track known sites and discover new ones (Fig. 4 a,b).⁵⁴

While artificial intelligence (AI) offers promise for archaeological research, it's not a guaranteed solution or a magic bullet. AI methodologies face limitations that require attention. A key constraint is the need for large datasets to train, calibrate, and validate AI models. The limited availability of large, representative samples can hinder AI model training performance. Additionally, AI model accuracy is often evaluated using samples from a specific archaeological context or region. This limits generalizability to the diverse complexities and heterogeneity encountered in real archaeological surveys. Therefore, these limitations present challenges that can be transformed into opportunities for further development of AI applications in archaeological remote sensing.⁵⁵

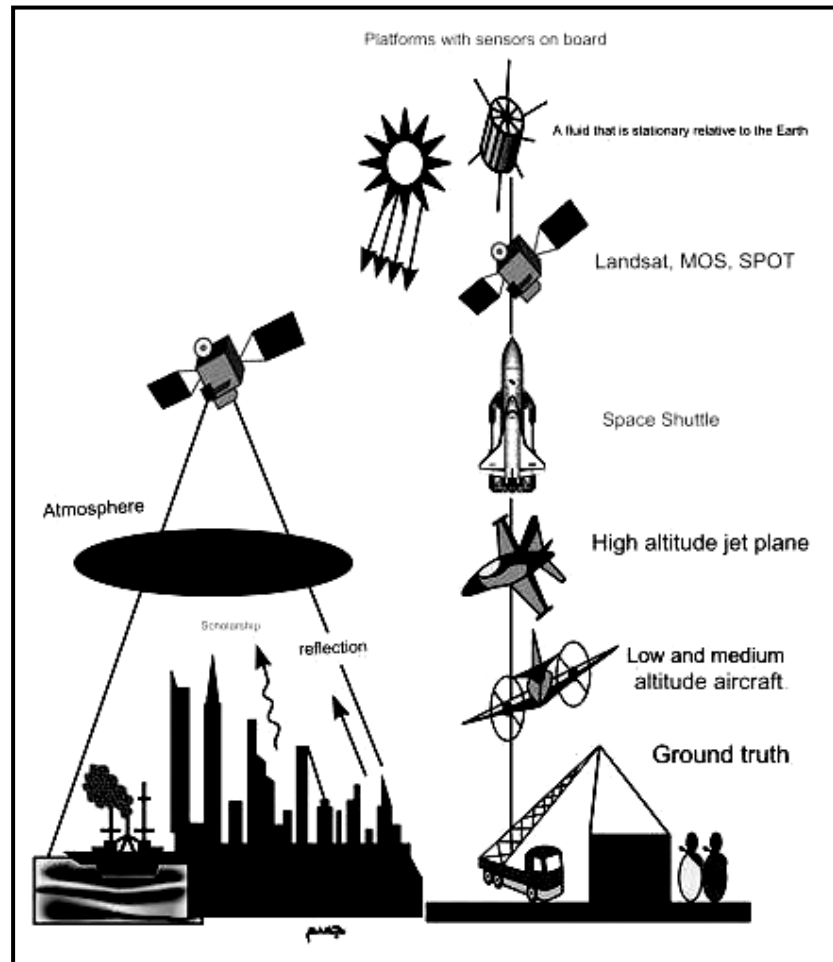


(Fig. 4a) Diagram of Remote Sensing Applications.

Luo, "Airborne and spaceborne remote sensing," 111280 (Fig. 1).

(Fig. 4b) A detailed illustration of the different platforms used for remote sensing.

<http://arab-ency.com.sy/tech/details/118/2>



Conclusion:

The following key points highlight the significant contributions of artificial intelligence (AI) and remote sensing to the field of archaeology:

- Artificial Intelligence (AI) empowers archaeologists by streamlining crucial processes like machine learning, photo analysis, and 3D modeling of artifacts and sites. These intelligent systems can enhance image accuracy, identify missing artifact parts, and reconstruct historical environments.
- AI techniques assist in archaeological site detection and location through data analysis from remote sensing and aerial photography, pinpointing areas with potential archaeological remains.
- AI complements archaeologists, not replaces them. It accelerates data analysis and site discovery while human expertise remains vital for accurate interpretation.
- AI acts as a powerful analytical tool, boosting research efficiency. However, human creativity and historical context understanding are irreplaceable in archaeological work.

- Satellite data offers archaeologists a cost-effective and efficient way to explore vast areas globally without needing on-site presence.
- Traditional methods, like pedestrian surveys, involve teams walking at set distances searching for archaeological evidence.
- Remote sensing refers to acquiring data about Earth's surface without physical contact, allowing for the detection of buried sites through aerial and satellite imagery.
- Remote sensing can be used to study the development and monitor temporal changes of archaeological sites by comparing satellite images taken at different periods.
- Remote sensing helps monitor archaeological sites and historical monuments for preservation purposes, including protection from natural and human threats.
- AI aids in creating and updating digital maps of archaeological sites, identifying areas with high archaeological potential.
- AI techniques contribute to archaeological discovery and excavation by analyzing geophysical data and archived information to target areas with high probability of finds.
- Deep learning algorithms analyze aerial and satellite images to identify archaeological sites and environmental changes, aiding discovery and excavation efforts.
- AI facilitates predictions about potential archaeological sites and future changes in their surroundings, leading to new discoveries.
- AI allows for the development of interactive virtual reality experiences, making ancient sites accessible to a wider audience.
- AI helps protect archaeological sites through surveillance with image recognition technology, deterring vandalism and theft.
- While beneficial, modern technology can be expensive, posing a challenge for institutions and researchers with limited resources.

In conclusion, remote sensing and artificial intelligence have revolutionized archaeology, offering powerful tools for exploration, analysis, and preservation. From cost-effective satellite surveys to AI-powered site prediction, these advancements are transforming the field. While human expertise remains crucial for interpretation and context, AI acts as a valuable partner, accelerating data analysis and discovery. By embracing these technologies and fostering collaboration between archaeologists, AI specialists, and geospatial scientists, we can unlock the full potential of this new era in archaeological research, leading to a deeper understanding of past societies and a richer tapestry of human history.

Abbreviations:

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|-----------------------------------|---|
| <i>Archaeol. Prospect.</i> | <i>Archaeological Prospection.</i> |
| <i>IANS</i> | <i>Interdisciplinaria Archaeologica - Natural Sciences in Archaeology.</i> |
| <i>ICAECIS</i> | <i>International Conference on Advances in Electronics, Communication, Computing and Intelligent Information Systems.</i> |
| <i>IJRAR</i> | <i>International Journal of Research and Analytical Reviews</i> |
| <i>JAS</i> | <i>Journal of Archaeological Science.</i> |
| <i>Remote Sens.</i> | <i>Remote Sensing.</i> |
| <i>RSE</i> | <i>Remote Sensing of Environment.</i> |
| <i>SAA</i> | <i>A Journal of the Society for American Archaeology.</i> |

Footnotes:

- ¹ Ḥaīdar, Kāmil, *Manhağ albaḥt al'aṭarī wa Altārīḥī* (1st ed., Lebanese Thought House, Lebanon, 1995), 11.
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