

*The Integration of Modern Field Technologies (UAVs and
Photogrammetry) in Re-reading the Spatial History of the Hippo
Regius Site*

1- Youcef Karkar, (Algeria)*, LECMMA laboratory
youcef.karkar@univ-alger2.dz

2- Mohamed Arbaoui, (Algeria), LECMMA laboratory
mohamed.arbaoui@univ-alger2.dz

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Abstract:

Technology has revolutionized archaeological studies, with tools like drone photogrammetry and advanced digital cameras becoming central to site discovery, documentation, and analysis with unprecedented precision. The process begins with drones capturing multiple overlapping images, which are then processed using photogrammetry techniques to create detailed **3D models** of the site. These models are subsequently utilized with specialized computer software (such as CAD and GIS) to produce accurate architectural and geographical plans. This technological integration not only enhances the efficiency and speed of fieldwork but also ensures comprehensive and precise documentation, enriching our understanding of ancient civilizations and preserving their cultural heritage effectively.

Keywords: 3D Modeling; Photogrammetry; Computer Software; Architectural Plans; Cultural Heritage Preservation; Archaeology.

ملخص:

لقد أحدثت التكنولوجيا ثورة في الدراسات الأثرية، حيث أصبحت أدوات مثل التصوير المساحي بالطائرات بدون طيار والكاميرات الرقمية المتقدمة محورية في اكتشاف المواقع وتوثيقها وتحليلها بدقة غير مسبوقة. تبدأ العملية بالطائرات بدون طيار التي تلتقط صوراً متعددة متداخلة، والتي تتم معالجتها بعد ذلك باستخدام تقنيات التصوير المساحي لإنشاء نماذج ثلاثية الأبعاد مفصلة للموقع. تُستخدم هذه النماذج لاحقاً مع برامج الكمبيوتر المتخصصة مثل *CAD* و *GIS* لإنتاج مخططات معمارية وجغرافية دقيقة. لا يؤدي هذا التكامل التكنولوجي إلى تعزيز كفاءة وسرعة العمل الميداني فحسب، بل يضمن أيضاً توثيقاً شاملاً ودقيقاً، مما يثري فهمنا للحضارات القديمة ويحافظ على تراثها الثقافي بشكل فعال.

كلمات مفتاحية: نمذجة ثلاثية الأبعاد،، تصوير مساحي،، برامج كمبيوتر،، مخططات معمارية،، الحفاظ على التراث الثقافي،، علم الآثار.

- Introduction:

Documenting archaeological sites with scientific precision poses a formidable challenge for researchers in archaeology and cultural heritage, particularly as countless historical landmarks face escalating threats from natural degradation and anthropogenic impact. In recent decades, however, a remarkable evolution in digital documentation techniques has emerged, fundamentally transforming how we record and preserve our shared past. Among these advancements, aerial photography utilizing unmanned aerial vehicles (UAVs or drones), coupled with sophisticated photogrammetric image processing and digital engineering drawing, has provided archaeologists with tools of unparalleled accuracy and efficiency, far surpassing the capabilities of

traditional methodologies. This article explores how these innovative technologies are reshaping archaeological practice, enabling a more comprehensive, precise, and sustainable approach to heritage documentation in the 21st century.

In this context, this work presents an applied experimental study focused on documenting the archaeological site of Hippo Regius in Annaba. Leveraging the aforementioned cutting-edge digital technologies, the research aims to evaluate their scientific and practical feasibility within the broader framework of archaeological heritage documentation.

1- Historical framework:

Hippone, an emblematic city of ancient North Africa, was extensively studied by numerous Roman historians, including Livy, who mentioned it in his account of the First Punic War¹. As for its founding, the historian Sallust attributes its creation to the Phoenicians². Geographically, Hippo is located southwest of the current city of Annaba, on the banks of the Seybouse River, approximately 2 km from it³. It was built between two hills, one of which houses the mound of Bishop Saint Augustine.

The Phoenicians established one of their trading posts there around the 9th century BCE⁴. Subsequently, from that same century, the city fell under Carthaginian control. However, with the decline of Carthage and its defeat at the Battle of Himera in 480 BCE, Hippone came under Greek influence.

During the Numidian period, the city gained a privileged position. After the Second Punic War, specifically in 202 BCE, Massinissa and

¹ Tite Live, *Histoire Romaine*, Tra :M. Nisard, Tome XXIX ,dubochet et compagnie Editeurs,Paris,1839, XXIX, 3, 7.

² Salluste, *Guerre De Jugurtha, œuvres complètes*, Tr: Charles Durosier, Librairie Garnier Frères, Paris, 1865, XIX.

³ Gsell (St), *Alas Archéologique de l'Algérie*, Adolphe Jourdan, Fonteoing, Alger.Paris,1911, F9, notes59.

⁴ Mansouri (Ka), réflexions sur les activités portuaires d'hippo regius (Hippone-Annaba) pendant l'antiquité, *Africa Romana*, XIV, 2002, p514.

his sons made it a royal city (Hippo Regius)⁵. From the 1st century BCE, it became a dependency of the Roman Empire's possessions, and later was elevated to a Roman city under the reign of Emperor Octavian Augustus.

Throughout the first three centuries CE, Hippone established itself as one of the wealthiest cities in ancient North Africa. By the end of the 4th century CE, it evolved into the capital and a major center of Western Christian thought. The Roman presence in the city concluded with the arrival of the Vandals in 431 CE, who subsequently made it their own capital.

2.Materials and Methods :

2.1.Photogrammetry:

Photogrammetry is the science of extracting reliable measurements from two-dimensional (2D) images, usually photographic. Photogrammetry encompasses methods of image measurement and interpretation in order to derive the shape and location of an object from one or more photographs of that object. In principle, photogrammetric methods can be applied in any situation where the object to be measured can be photographically recorded. The primary purpose of a photogrammetric measurement is the three-dimensional reconstruction of an object in digital form (coordinates and derived geometric elements) or graphical form (images, drawings, maps). The photograph or image represents a store of information which can be re-accessed at any time. For the reconstruction of an object from images it is therefore necessary to describe the optical process by which an image is created. This includes all elements which contribute to this process, such as light sources, properties of the surface of the object, the medium through which the light travels, sensor and camera technology, image processing, and further processing (Fig1).

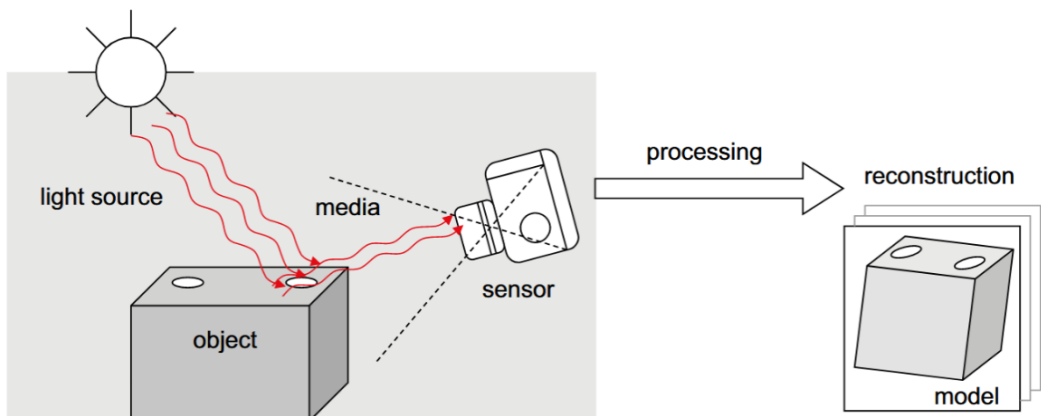


Figure 1 : From object to image.

Methods of image interpretation and measurement are then required which permit the image of an object point to be identified from its form, brightness or colour distribution. For every image point, values in the form of radiometric data (intensity, grey value, colour value) and geometric data (position in image) can then be obtained. This requires measurement systems with the appropriate geometric and optical quality. From these measurements and a mathematical transformation between image and object space, the object can finally be modelled.

Various photographic cameras are used to capture the artifact with all its contents and dimensions, providing a detailed image of it. This process begins by taking general shots, followed by detailed shots of each part, ensuring an overlap of 30% horizontally and 10% vertically between these shots. Ordinary cameras are used without artificial lighting, and these are connected to computers to provide a complete visualization of the artifact.

Photogrammetry relies on various devices and tools that aid in completing all its stages. The more modern and advanced these tools and devices are, the more effort and time they save us.

2.2.Cameras:

Photography has witnessed tremendous advancement with the evolution of digital technology over the past three decades. While digital cameras still rely on the same optical principles as film cameras, they use a light-sensitive chip instead of film. This chip converts light energy into electrical signals, which are then stored as digital data on a memory card. This data can subsequently be edited on computers or mobile phones.

Cameras come in many shapes, sizes, and resolutions, with a wide variety available. For instance, we can mention: DSLR cameras, Mirrorless cameras, Compact cameras, Action cameras, Smartphone cameras...

2.3. Drones (UAVs):

Technological advancements have seen rapid growth, especially in the field of engineering. Among these technologies, photogrammetry using Unmanned Aerial Vehicles (UAVs) has gained widespread use across various domains. The application of aerial photogrammetry via UAVs can generate geospatial information, making it a fundamental basis for decision-making related to the planning, management, and evaluation of sites.

They are defined as unmanned, reusable aerial vehicles that can be operated remotely or autonomously. When comparing UAVs to manned aircraft, the fundamental difference between the two systems is clearly the absence of a physical pilot on board the UAV.

The term UAV is widely used in fields such as computer science, robotics, artificial intelligence, aerial photography, and remote sensing.

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Photogrammetry using Unmanned Aerial Vehicles (UAVs) bridges the gap between traditional remote sensing and conventional close-range aerial photogrammetry. This statement refers not only to the scale of ground resolution but also to the ability to capture images from any location and at any angle.

Modern Unmanned Aerial Vehicles (UAVs) allow for the recording and tracking of the position and orientation of their onboard sensors within either a local or global coordinate system. This capability makes UAV-based aerial photography a novel and powerful tool for photogrammetry.

UAVs vary in type, size, and cost. Among the most significant advantages of using UAV photogrammetry are:

- It can be utilized for both small and large-scale projects.
- It offers low-cost alternatives compared to traditional manned aerial photography methods.
- We can implement the work immediately or at a suitable time.

2.4. Agisoft Metashape:

Agisoft Metashape is a standalone software product that performs photogrammetric processing of digital images and generates 3D spatial data for use in GIS applications, cultural heritage documentation, and visual effects production, as well as for indirect measurements of objects of various scales. This software provides a platform for cultural heritage specialists to create virtual reality scenes, textured 3D meshes, orthographic projections, georeferenced maps, and much more from images and/or laser scans in a fully automatic manner.

2.5. Autodesk Autocad:

AutoCAD is known term when it comes to 3D and 2D CAD design. AutoCAD software is a tool that facilitates the process of designing and communicating the end results with others. In this age most structures that are built are based on CAD drawings. The majority of them use AutoCAD.

Most people associate AutoCAD with architectural house design; however, there are many different industries that use AutoCAD. For example, many: geographical, mechanical, electronic, AEC, multimedia, electrical, surveying, engineering, town planning, and even garment companies' use AutoCAD. Building Information Modeling (BIM) features have also been recently added to the list of things that AutoCAD can do.

3. Photogrammetric Documentation of Hippo Regius:

To document the archaeological site of Hippo Regius, the initial step involved aerial photography using an Unmanned Aerial Vehicle

(UAV or drone). This process allowed for the collection of accurate, high-quality images covering the site from multiple angles, enabling comprehensive documentation of both the surface structure and visible architectural features.

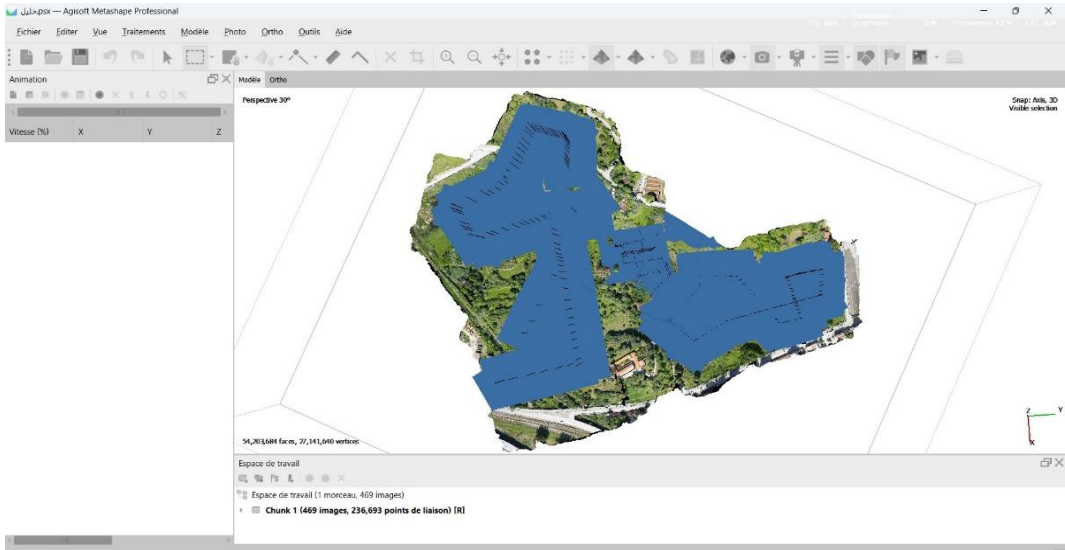


Figure 2 : The Images We Captured With The Drone

After completing the image acquisition, the captured photos were uploaded to Agisoft Metashape software. The program then processed these images using photogrammetry techniques to generate a precise 3D model of the site, along with an orthophoto map and georeferenced data. This digital survey significantly contributed to establishing an accurate visual database that can be effectively used for analysis, documentation, and the preservation of the site's archaeological heritage.

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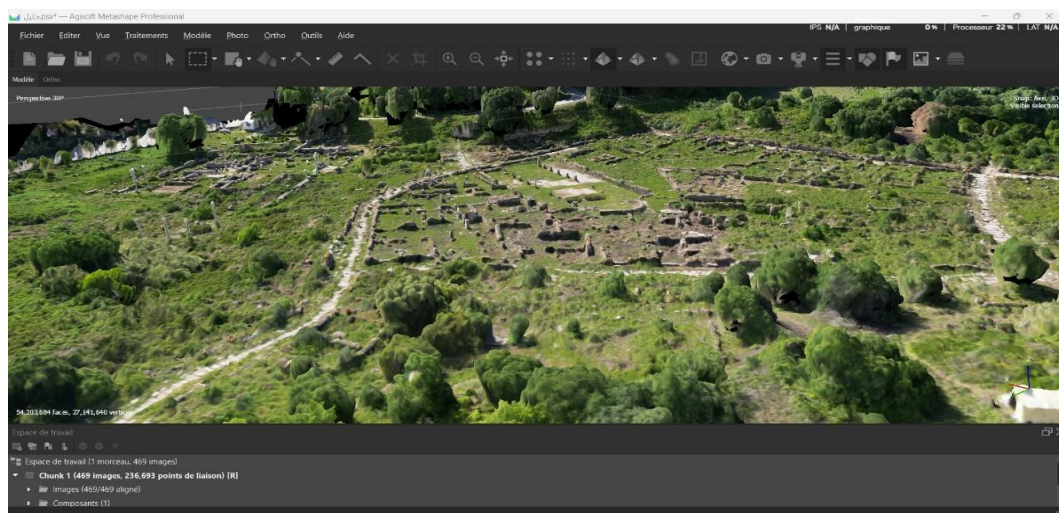


Figure 3 : Photogrammetry of the Hippo Regius Site

4. Delimitation of the Hippo Regius Site and Redrawing of its Plans:

Upon completion of aerial image processing using Agisoft Metashape software, the final products, such as the orthophoto and the Digital Surface Model (DSM), are extracted in supported formats like tiff or dxf, while preserving their coordinates. This data is then imported into AutoCAD software, where the orthophoto is first loaded as an accurately georeferenced base map within the established geographic system.



Figure 4 : The boundaries of the Hippo Regius site were drawn in red

Following this, drawing tools in AutoCAD are used to trace visible archaeological elements within the image (such as walls, foundations, roads), and to precisely draw the site's boundaries and features. This integration between Agisoft and AutoCAD allows for the creation of a documented and analyzable engineering plan, which is used for documentation purposes, restoration, or urban planning of archaeological areas.

After the drawing process is complete, the drawing scale and north arrow are inserted in the appropriate corner of the plan, based on the geographical orientation of the image. Compass data or the geographic grid in Metashape can be used to accurately determine true north before transferring it to AutoCAD. Then, the dimensions of the drawn elements are reviewed using the DIST or DIM measurement tools to ensure they match the real measurements. After all this, the image is extracted in various formats for use in several fields.

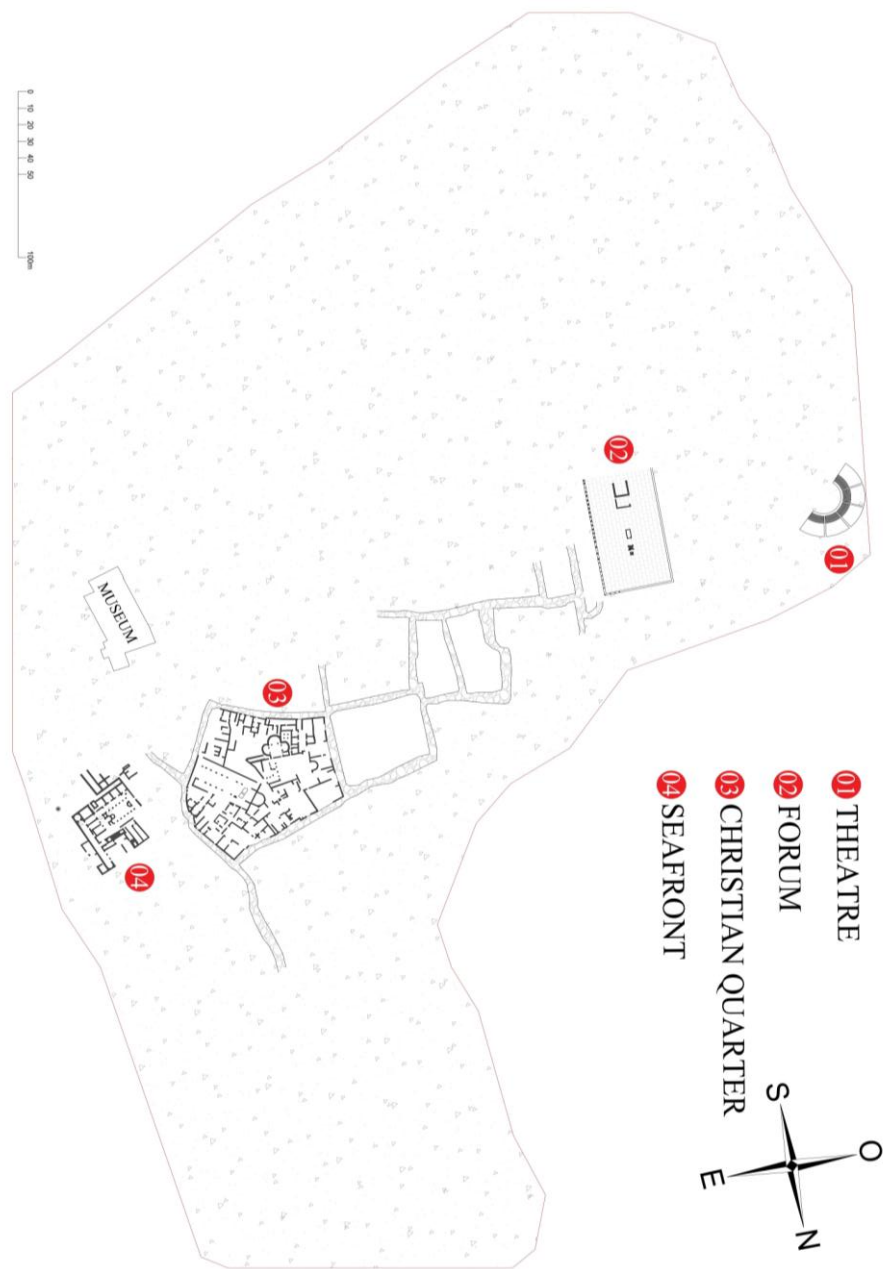


Figure 5 : Plan of Some Landmarks of Hippo Regius

5. Conclusion:

This work represents an integrated field experiment in the utilization of modern digital tools for archaeological site documentation. A scientific methodology was adopted, beginning with aerial photography via Unmanned Aerial Vehicles (UAVs/drones), progressing through image processing using Agisoft Metashape software, and culminating in the production of a precise site plan using AutoCAD software.

This work proved its effectiveness in terms of high accuracy of results and significant savings in time and effort, compared to traditional methods used in archaeological surveying and plan drawing.

The use of drones allowed for comprehensive and rapid site coverage, providing high-quality images from various angles, a capability not offered by traditional surveying instruments like theodolites or total stations, which rely on limited point measurements and require more time and effort. Furthermore, relying on photogrammetry via Metashape enabled the production of accurate 3D models and orthophotos, which served as reliable references for drawing boundaries and features within AutoCAD, while adhering to technical standards regarding drawing scale, north direction, and geographic coordinate system.

The obtained results confirm that the integration of drone technologies, digital processing, and engineering drawing opens new horizons in the field of archaeological documentation, providing researchers with effective tools to preserve and value heritage according to precise and contemporary scientific principles.

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