AUTOMATA BLOG POST #7 (INRIA, April 2026) - Creation of 3D models for pottery and lithics

How can we document thousands of artefacts without constantly manipulating them? As archaeological excavations continue to uncover enormous quantities of objects, museums and conservation centers are facing growing challenges in storing, studying and preserving these collections. To support archaeologists in addressing these challenges, artefact digitization techniques allow these remains to be studied and classified despite their fragility, even when they are located thousands of kilometers away from the researchers studying them.

For lithic tools and pottery fragments, the objective is to generate detailed 3D models that accurately reproduce both the geometry and appearance of the original artefacts, allowing researchers to explore them directly on a computer screen. To achieve this, the main technology used in the AUTOMATA project is **photogrammetry**.

What is photogrammetry?

To understand the shape of any object, humans mainly rely on their own eyes, looking at the object from different angles to build a mental image of its geometry. Photogrammetry works in a very similar way but uses a camera to mimic the eye. By taking photographs from all around an object (Figure 1), specialized software can identify matching details between the images and use them to reconstruct the object in 3D. In a way, photogrammetry works like solving a puzzle where every image contains small pieces of information that are assembled to get the final 3D model.

Figure 1 - Taking manual pictures of an object for photogrammetry at Archeovision

Capturing many high-resolution photographs is essential for photogrammetry. Each image provides a slightly different point of view, helping the software better understand the

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geometry of the artefact. Missing angles or blurry pictures can create holes or distortions in the final model.
Furthermore, photogrammetry relies on a simple but important assumption: an object should look the same no matter the angle you view it from. This statement is sometimes hard to fulfill, especially for shiny appearances like polished stone tools, glazed ceramics or even for more complex light behavior such as the translucency of crystals. As a result, lighting becomes a critical factor that must be carefully controlled to ensure reliable results. In the AUTOMATA project, we chose to use an LED ring mounted on the camera (Figure 1) to minimize specular highlights and reduce shadows.

On which support should we place the artefact and why does it matter?

To capture photographs from every angle, the ideal situation would be for the artefact to levitate in mid-air and remain perfectly still while being photographed. Unfortunately, such technology is not available in most archaeology laboratories, so artefacts must instead be placed on physical support during acquisition.

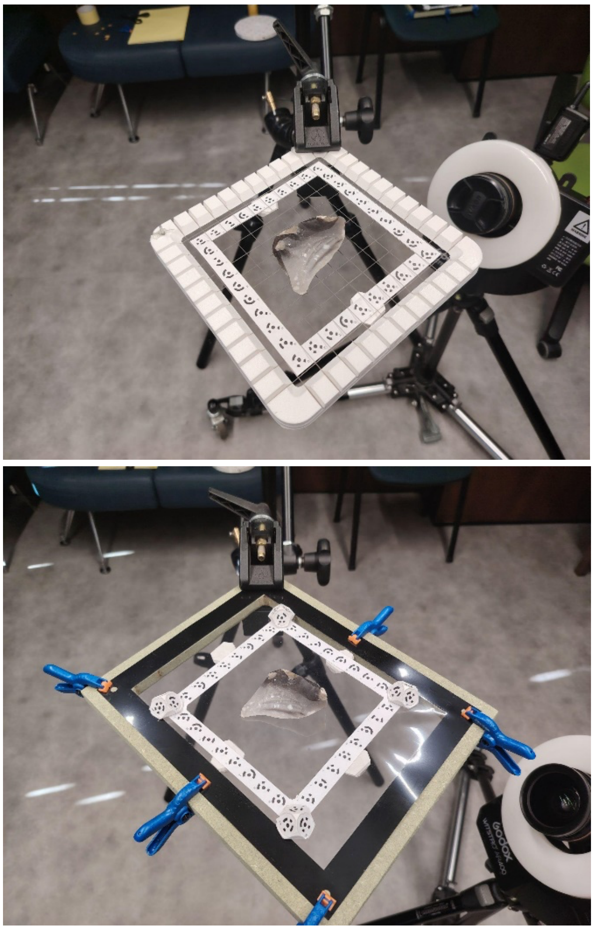

Figure 2 - Studied support for photogrammetry at Archeovision with nylon strings (left) and transparent support (right)

As shown in Figure 2, we experimented with several types of supports at Archeovision, including nylon strings and transparent stands. These solutions help expose both the upper and lower parts of the object while minimizing the areas hidden from the camera. However, choosing the right support is more challenging than it may first appear.

Transparent support, for example, can create unwanted reflections that interfere with the reconstruction process. Similarly, supports that are too thick may hide parts of the artefact introducing errors into the final 3D model. For now, the chosen support to balance these limitations is a circular piece of Plexiglas (Figure 3).

Figure 3 - Last support designed by Archeovision for photogrammetry

Another important aspect is the presence of visual patterns around the object (Figure 2 and Figure 3). Photogrammetry software relies on recognizable details to help us to understand where the camera is placed. For this reason, static patterned backgrounds or markers are often added around the object to improve the alignment of photographs.

By carefully designing both the lighting setup and the object support, it becomes possible to obtain more complete and accurate 3D reconstructions (Figure 4).

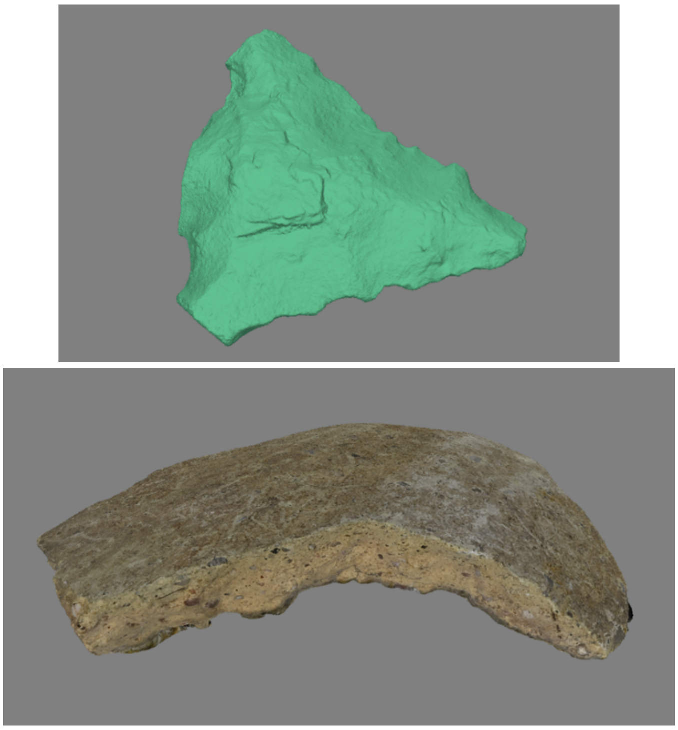

Figure 4 - Examples of 3D reconstructions of lithics showing only geometry (left) and ceramics showing appearance registered on the geometry (right) from Archeovision

How can we automate the process?

The main goal of the AUTOMATA project is to automate the entire workflow. To achieve this, a robotic arm will be used to handle the camera and reproduce the same movements and viewpoints that a human operator would normally perform during image acquisition.

At INRIA, we tested this approach using our in-house system called ***La Coupole***. Originally designed to measure the visual appearance of a wide variety of surfaces, *La Coupole* combines 1080 LEDs, a rotating table, a robotic arm, and a camera mounted directly onto the arm (Figure 5).

Figure 5 - Picture of La Coupole acquiring a ceramic fragment (left) and points of view acquired (right)

This setup gives us far greater control over the acquisition process. The robotic arm can move the camera with high precision around the artefact, ensuring consistent image capture and repeatable trajectories. It can also reach viewpoints that may be difficult, or simply impossible, for a human operator to achieve manually. Furthermore, with a fixed setup, the acquisition process can be faster than a normal photogrammetric acquisition.
The robot arm is programmed to maintain a constant distance between the camera and the object while following a dome-shaped trajectory around the artefact. This ensures that every part of the object is photographed from multiple angles, maximizing the information available for the 3D reconstruction.
In this configuration, the samples are placed on a surface covered with markers before being photographed and then turned over to capture the opposite side. The two reconstructed faces are then merged to create the final 3D model of the artefact. However, this merging process strongly depends on the thickness and geometry of the object. Thick artefacts are generally easier to align, while thinner or irregular shapes can make the reconstruction more challenging.
As in the manual photogrammetry workflow, the marker-covered background also plays an important role in helping the software estimate the camera position during acquisition. However, because in this configuration the background changes between the top and bottom acquisitions when the object is flipped, it cannot be used directly to merge both sides together. In this case, the contours of the artefact must be accurately identified to correctly align the two reconstructions (Figure 6).

Figure 6 – Preview images of ceramic sample taken by La Coupole (left) with its associated mask (right)

With this pipeline, we obtain accurate 3D models (Figure 7) capable of preserving both the general geometry and fine surface details of archaeological artefacts, allowing researchers to study, measure, and share them digitally. By combining this pipeline with the grasping component of the AUTOMATA project, we can digitize artefacts while minimizing direct human interaction with the original object.

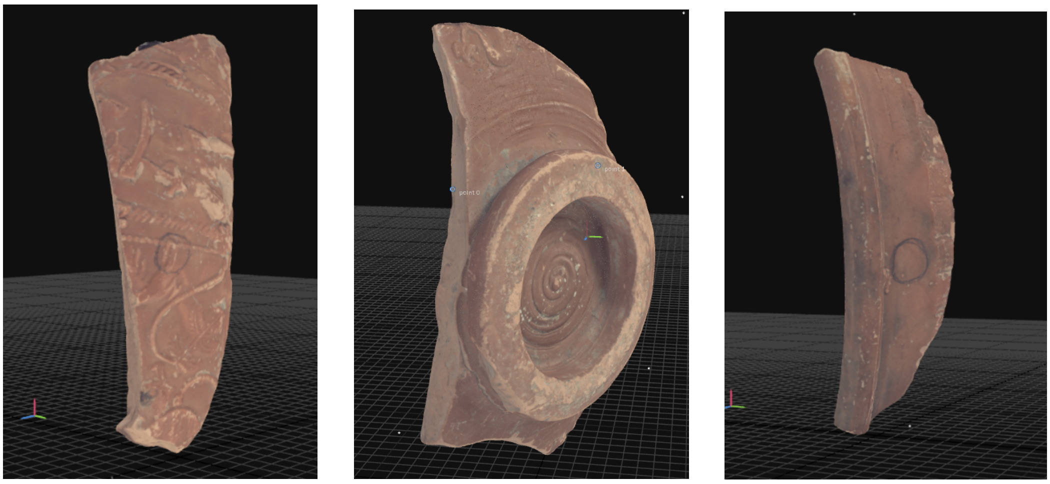

Figure 7 - 3D models of ceramics taken from La Coupole

What is next?

Although these first results are promising, many challenges remain before photogrammetry can become a fully autonomous and reliable digitization solution for archaeology. Future work will focus on adapting the robot arm to work with the developed transparent support and improving the robustness of the system when dealing with highly reflective or thin artefacts that can introduce errors in the final 3D model.