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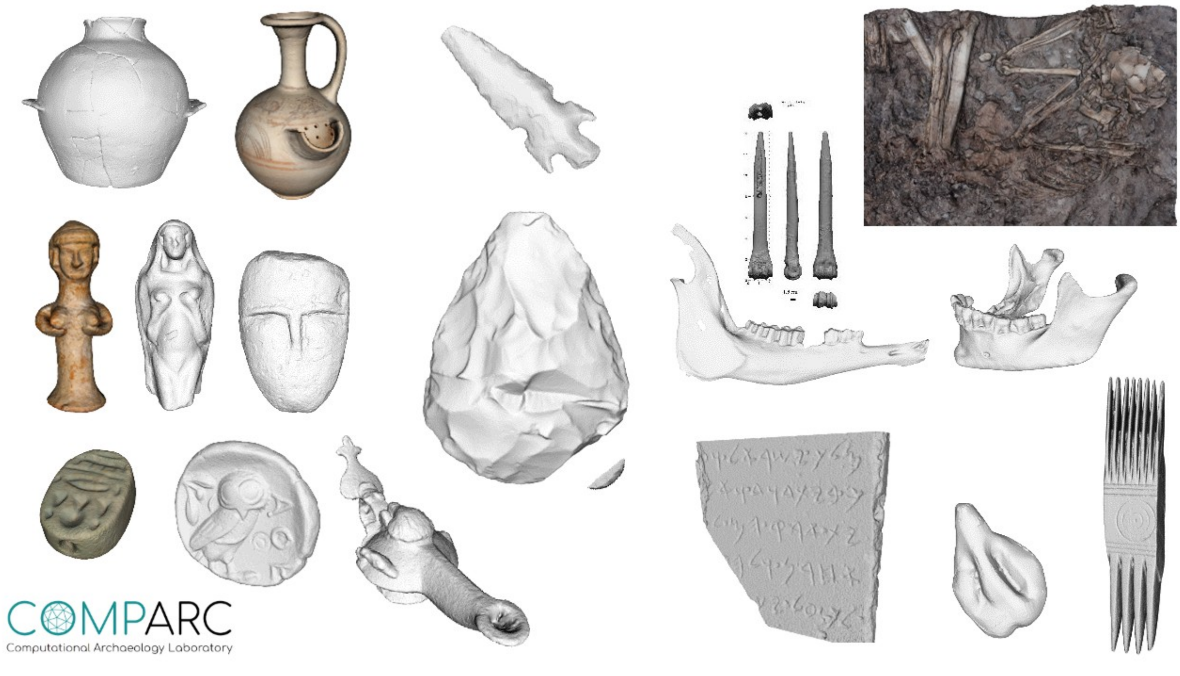
<u>**BLOG POST #6 (April 2026) - Working in AUTOMATA: The roles of the Computational Archaeology Laboratory of the Hebrew University of Jerusalem (HUJ)**</u>

At the Computational Archaeology Laboratory, we address archaeological questions through computational methods. We are first and foremost archaeologists, specifically prehistorians, conducting archaeological research using computational tools. Concentrating on 3D digital models of archaeological artefacts we harness and develop algorithms and computational procedures to analyze the geometry and morphology of archaeological finds, in ways that are otherwise impossible. The data and insights deriving from such analyses lead the way to discussing technological, economic, social, or cognitive issues and assist in answering broad fundamental archaeological questions.



Various Archaeological finds 3D modeled at the Computational Archaeology Lab. (displayed in CompArchView, our in-house 3D visualization software)

As part of the AUTOMATA project, we lend our expertise to all aspects of 3D modeling and analysis. We started our journey with contributing to the various deliverables of WP.2, including describing and defining 3D data collection and modelling methodologies, scanning and model analysis scenarios and various user requirements, presenting the state of the art in current technologies and methodologies for 3D digitization of ceramics and lithics, and exploring multiple aspects of system specifications.

How to make a 3D model?

3D modelling stands at the heart of the AUTOMATA project and is the first step in the project's data collection procedure. 3D data, the building blocks of 3D digital models, may be collected in various ways, using different technologies. One of the first decisions the AUTOMATA team faced was – how to collect the 3D data for the construction of 3D models? What technology should be used and in what way?

The considerations were manifold: the process should be quick and the devices light and affordable; the artefact size range is small, and the accuracy must be high; the resolution needs to balance the ability to capture minute intricate geometry (heavy files) with limited archiving space and analysis needs (lightweight files).

Three optional technologies were considered – the inbuilt iPhone LiDAR system, Structured Light scanning and Photogrammetry. The iPhone LiDAR was considered for its affordability yet suffers from low resolution, inadequate for small objects. Structured Light excels in accuracy, yet devices tend to be expensive. Photogrammetry offers the best, true to life, appearance yet struggles with accurate capture and produces excessively heavy models.

Structured light
iPhone LiDAR

Photogrammetry

Various ways to collect 3D data

This is in a nutshell; for us and the rest of the team it meant diving deep into user needs, robotic considerations, technological specifications and more. After long deliberations and detailed discussions Photogrammetry was chosen as the most appropriate 3D data collecting technology for the project and off it went to be appropriated and integrated in the AUTOMATA robotic station.

What is a good 3D model?

The collected 3D data is used to create a digital 3D model. In a very simplified way, a model is based on a point-cloud – a group of points (called vertices) defining the outer shape of an object, where the location of each point in space is identified by three coordinates (X,Y,Z). The point-cloud is turned into a mesh - each point is connected by lines (called edges) to the points around it, creating 2D surfaces between the points (called polygons or faces). The mesh is then turned into a model – each polygon is filled in by texture, color, sheen and other visual traits to create the appearance of the model (this is called rendering).

For the AUTOMATA project, we must ensure that all 3D models automatically produced along the process are 'good' – properly constructed and accurately recording the scanned artefact. What is a 'good' model? This is a philosophical question 😉 yet at its base the model needs to be 'watertight', properly aligned and fused, with clear boundaries and no outliers. What does all this mean? 'Watertight' means that there are no holes in the mesh, that all the points are connected, with full polygonal coverage of the surface of the object. 'Aligned and fused' means that there are no duplicated or overlapping points or faces, with no 'outliers' – no points that deviate from the actual boundaries of the object represented by the model.

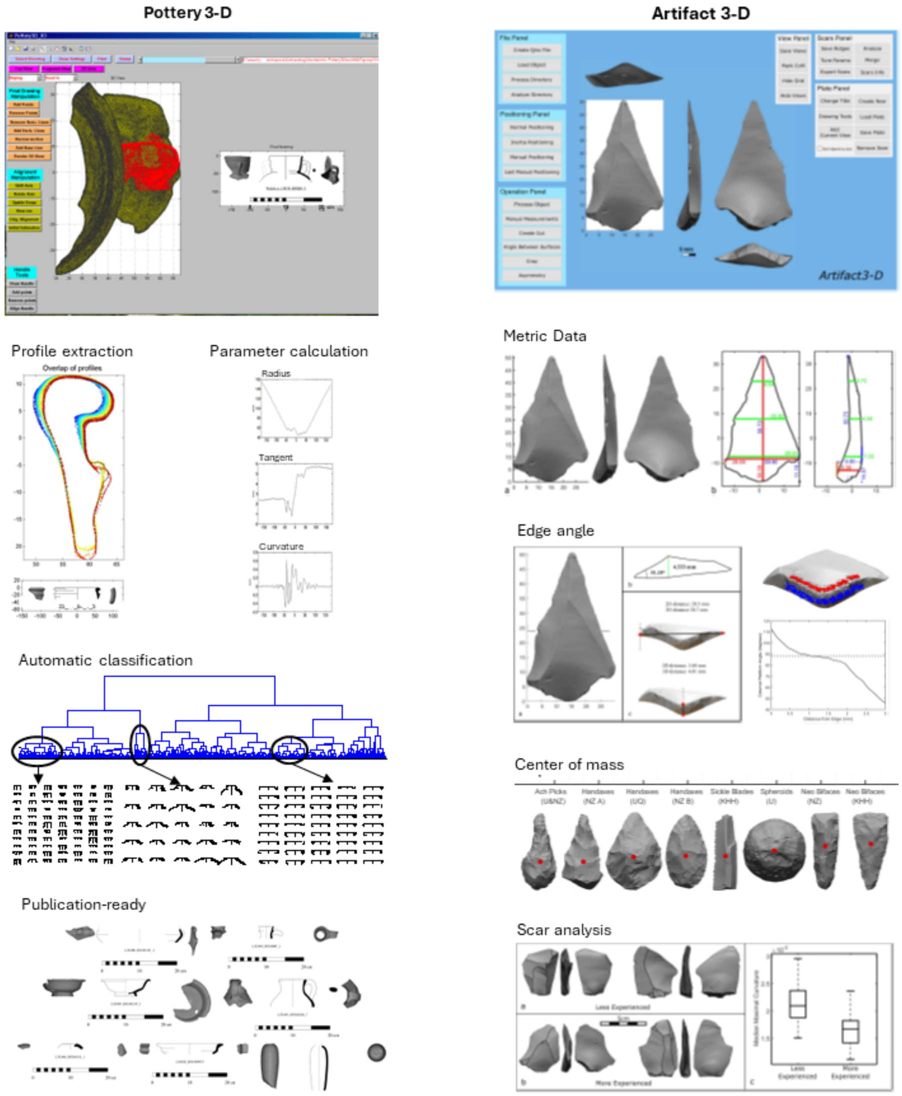
Together with the AI team of the project, we conceptualized how AI and other algorithmic procedures could assist in this quality assurance task on-the-fly and devised a set of measurements and statistical tests for this purpose. These would be run on every produced 3D model to assure that it upholds at least these basic quality requirements before moving on to the next stage of analysis. Many more exciting challenges are still up ahead – for example, how can we assure that the model is not only technically and structurally sound, but that it accurately represents the real-life object? That the shape and appearance of the 3D model reflect what is really there? Interesting things to think about and there are more to come…

Future directions

Ultimately, we ask – what would users do with the archived data collected through the AUTOMATA project? What would the 3D models be used for? Beyond visualization, beyond the ability of a user to view and unaidedly examine 3D models, we plan to integrate computational tools in the database that would allow users to perform various geometric analyses on the 3D models of lithic and ceramic artefacts making up the assemblage.

Traditionally, ceramic types are identified by vessel profiles. The ceramic profile (a vertical cross-section of the vessel) tells the researcher if a vessel is open or closed, what are its size and proportions and how its outline curves. These characteristics of the profile help researchers identify differences and similarities between vessels and assign them to typological groups. For the AUTOMATA project, we will implement the basic functions of Pottery 3-D, an in-house developed software, for automatic extraction of vessel profiles, using algorithms based on ceramics' inherent axial symmetry. Possible additional functions will include the ability to produce a 'publication-ready' profile illustration, perform various measurements and automatic typological clustering.

For the analysis of lithic artefacts, we plan to implement procedures from another in-house software – Artifact 3-D. Such functions will establish repeatable positioning of the 3D models based on the artefact's individual inherent geometry, which will allow the execution of consistent automatic measurements, identification of the center of mass, asymmetry assessment, scar tracing and edge angle calculation.



Pottery 3-D and Artifact 3-D analytical procedures

Lithics?

The most common find in prehistoric sites are lithics – flint and stone artefacts. The incorporation of lithics in the documentation and analysis goals of AUTOMATA presents idiosyncratic considerations distinct from those of ceramics. On the technical side of 3D scanning, lithics, particularly flint, pose unique challenges deriving from their materiality – they may be somewhat translucent, with shiny, reflective and smooth surfaces – all traits that impact the way light interacts with the object (goes through, bounces back, disperses) making it difficult to capture their 3D data. Furthermore, flint tools tend to be thin and flat, which makes it challenging to capture and then define their edges, and also poses difficulties for robotic handling.

Furthermore, AUTOMATA plans to integrate an interpretative stage of analysis of the produced 3D models – AI based typological identification. Even before the technological and computational endeavors that will be performed to achieve this goal, some conceptional considerations need to be resolved and defined: How does lithic typology work? It is different than ceramic typology; it is multi-leveled, some parts of the definition are dependent on overall shape and proportion while others depend on minute geometry, scar definition and pattern recognition. These considerations not only impact the 3D modeling process (How to capture fine geometric details? what resolution is needed?) but also the machine-learning procedures that will be developed.

We thus lend our expertise in lithic analysis and 3D modelling on multiple levels, defining needs and limitations, identifying hurdles and resolving them, consulting in the development of AI approaches, and tying it all together for the integration of lithics in the AUTOMATA project.

Beyond 3D modelling and lithics, we are part of the project's stakeholders, representing universities as academic research institutes. Wearing this hat, we took part in defining user needs regarding both research and education, and in providing insights into institutional facilities and structural organization of space and finds. As non-European representatives, we offered perspectives on international transport needs and varying compatibility, border import/export regulations and other aspects that may go overlooked within Europe.

We look forward to our continued work, future challenges, small successes and big achievements as part of the AUTOMATA project team.