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DOCUMENTING MATERIAL AND TEXTUAL HERITAGE IN 3D: ISLAMIC MAGIC-THERAPEUTIC BOWLS AT THE MUSEO ORIENTALE 'UMBERTO SCERRATO', NAPLES

1. Introduction

In recent years, the digitisation of cultural heritage has emerged not only as a means of preservation and dissemination, but also as a catalyst for new research practices. This objective lies at the core of the project ITSERR (Italian Strengthening of the ESFRI RI RESILIENCE, https://www.itserr.it/), launched in November 2022 within the framework of the Italian National Recovery and Resilience Plan (PNRR). Coordinated at the national level by the National Research Council (CNR) in collaboration with the Universities of Palermo, Modena and Reggio Emilia, Torino, and Napoli L'Orientale, the project supports scholars in the field of religious studies by combining expertise in the humanities with digital and ICT tools for research, data management, preservation, and dissemination.

The main goal of ITSERR is to reinforce the Italian contribution to RESILIENCE (Religious Studies Infrastructure: Tools, Innovation, Experts, Connections and Centers, https://www.resilience-ri.eu/), a European Research Infrastructure included in the 2021 ESFRI Roadmap in the domain of social and cultural innovation. Led by the Fondazione per le Scienze Religiose (FSCIRE, Bologna-Palermo), RESILIENCE is designed to provide scholars with advanced tools and services for the study of religions and religious texts. ITSERR aims to consolidate the institutional, scientific, and technical presence of RESILIENCE in Italy, by increasing visibility and accessibility, promoting FAIR (Findable, Accessible, Interoperable, Reusable) principles, and developing strategies and services for data management and access to resources such as manuscripts, archives, laboratories, and collaborative networks. Within this framework, participating teams have been testing various digitisation approaches to establish effective methods for the digital acquisition and representation of manuscripts, inscriptions, and artefacts.

As part of ITSERR, Work Package 10 (ReTina - Religious Texts in the Nile Valley and Beyond) from the University of Napoli L'Orientale, had two aims: to develop guidelines for the digital archiving of textual materials with religious content, and to create a prototype application designed for their visualisation and annotation. The research focused on sources that are often complex in form and transmission, rare for their preservation, and endangered because of fragile conservation conditions or socio-political and military instability in the regions where they are located. These materials, preserved on different types of media, originate mainly from the Nile Valley, with extensions towards Ethiopia, Eritrea and the Arabian Peninsula, which together represent the 'beyond' of the title of the project.

As part of the research programme of WP10, the category of 'religious' was conceived in a broad and inclusive sense, encompassing texts, objects, and epigraphic artefacts. While texts and objects can be examined independently, inscribed objects require a dual level of analysis: the study of the material support, on the one hand, and of the text inscribed upon it, on the other. This dual nature of these items, which is simultaneously textual and material, has direct implications for their digital representation and cataloguing. It also affects the choice of the most appropriate ontologies and semantic models, which must be capable of describing not only the linguistic and structural features of the inscription, but also the physical characteristics of the object.

This broad definition of 'religious' reflects the diverse and often semantically ambiguous nature of the material examined by the working group. The term itself in fact does not carry a single and fixed meaning: its relevance may derive from the content of a text, from the symbolic or apotropaic functions of an object, or from the cultural and ritual contexts in which these artefacts were produced and used. As a result, the category encompasses sources that are heterogeneous in form, purpose, and transmission, and whose 'religious' character often emerges only when their material, textual, and contextual dimensions are considered together. On the textual side, descriptions of ceremonies, funerary texts, prayers, incantations, magical and apotropaic formulas, and lists of offerings are included. On the material side, it covers amulets, talismans, and magic, ritual or religious artefacts. The complexity of these sources is further heightened by the wide variety of languages and scripts attested in the region under study, ranging from Coptic and Meroitic to Old Nubian, Ge'ez, Ancient South Arabian and Arabic. Each of these systems is linked to distinct cultural and religious traditions, adding further layers of diversity to the interpretation of the materials.

To address these challenges, the team of L'Orientale is developing a prototype web application that enables scholars to interactively visualise and annotate 3D models, adding metadata and descriptive information that enrich or reinterpret the models. During the course of the research, existing annotation systems for cultural heritage data were examined, including Aïoli (http://www.aioli.cloud/) and Dynamic Collection Plus (Lund University, https://www.darklab.lu.se/digital-collections/dynamic-collections/), which offer different models and functionalities for the enrichment of textual and material datasets. Among the most relevant features of the prototype are a tagging system that allows materials to be categorised and thereby enhances their classification and retrieval, the interactive visualisation of 3D models, and the export of data and metadata in open formats such as XML. Implemented with an open-source software environment offering advanced tools for the management of three-dimensional cultural data, the prototype and the related procedures were conceived as adaptable resources that can be applied to a broader range of traditions, thus extending the impact of the work beyond the initial datasets.

The research, however, highlighted several critical issues. One of the most pressing limitations is the lack of digital infrastructures and archives specifically designed for ancient religious sources. This structural gap is further complicated by the fact that such sources are attested across a wide range of languages and scripts, and by the absence of semantic tools specifically developed to support their cataloguing and interpretation. In this regard, the team identified the need to rely on thesauri and ontologies, such as the CIDOC Conceptual Reference Model (CIDOC CRM), to harmonize definitions and ensure semantic interoperability across different datasets.

The datasets analysed within the project reflect the variety and complexity of the materials under investigation, ranging from manuscripts to inscribed and ritual objects. The Ethiopian-Eritrean manuscripts include some of the earliest Amharic chronicles, especially passages dealing with interreligious debate, and are currently being studied by T. Ranieri through digital transcription, in both Ethiopic script and Latin transliteration and lexical indexing of religious terminology. The *corpus* also includes the amulets of the Kerma culture (D'Itria 2023), documented in a relational database that consolidates dispersed finds and records both their intrinsic and contextual attributes (D'Itria, Ferrandino 2019); the Meroitic inscriptions currently examined by G. Ferrandino; and the Islamic magic-therapeutic bowls, which have been the subject of detailed linguistic and iconographic analysis by R. Giunta and M. Bernardini (Giunta 2018; Bernardini, Giunta 2025).

Taken together, these datasets illustrate the range and complexity of the materials addressed by the working group of L'Orientale and highlight the need for digital methodologies capable of managing different layers of textual, material, and contextual information. As the project progressed, it became increasingly clear that visual digitisation, whether in 2D or 3D, represents only one component of a broader and more articulated documentation process. To fully capture the nature of the objects under study, digital acquisition must be complemented by additional forms of analysis that document their material, and their technological and structural characteristics.

In this perspective, the aim of this article is to underline the value of integrated digitisation workflows, which become significantly more effective when visual recording is combined with analytical datasets and, particularly in the case of archaeological artefacts, with metadata derived from archaeometric investigations. Such data clarify not only the materials and technologies employed in the production of the objects, but also the forms of agency embedded in them: how they were made, by whom, where, and for what purposes.

The case study presented here concerns the magic-therapeutic bowls preserved at the Museo Orientale 'Umberto Scerrato' in Naples and outlines the stages that have shaped their ongoing investigation. It should be noted, however, that the work carried out so far has focused on digital acquisition and 3D modelling, while archaeometric analyses, identified as a crucial component for a more comprehensive understanding, are planned for a later phase and have not yet been undertaken.

2. Digital documentation and research transformation

The digitisation of cultural heritage materials has become an essential component of their study, preservation, and dissemination. Its rise was further accelerated by the COVID-19 pandemic, which forced institutions to adopt remote, virtual, and digital forms of access. The European Commission has supported numerous initiatives in this direction, including Europeana (https://www.europeana.eu/), ARIADNE/ARIADNEplus (https://ariadne-infrastructure.eu/), and EAGLE (https://www.eagle-network.eu/), all of which have promoted digital access, interoperability, and shared standards across the heritage sector.

Initially conceived as faithful digital renderings of physical materials, these resources have gradually become methodological instruments, influencing how scholars frame their questions, analyse evidence, and construct interpretation. While early efforts centred mainly on two-dimensional imaging, current practices rely on integrated, multidimensional, and multimodal approaches (Kelley, Wood 2018). The diversification of acquisition techniques, from high-resolution photography to structured-light scanning and photogrammetry (Remondino, Campana 2014), reflects the heterogeneous nature of cultural objects, whose materials, shapes, dimensions, and morphological features require tailored strategies.

Within this diversified landscape, traditional forms of documentation continue to play an essential role. Photography remains fundamental for recording inscriptions and manuscripts, and hand-drawn illustrations, grounded in close visual inspection, often capture morphological or technological details that standard photographs may miss. Whenever available, such drawings and transcriptions should be incorporated into digital archives, where they complement 3D data and contribute to linguistic and archaeological analysis.

At the same time, digital workflows increasingly incorporate three-dimensional acquisition, which opens analytical possibilities that extend well beyond visual reproduction. When 3D models are enriched with additional layers of information which could be analytical, technological, contextual, or textual, they support a more comprehensive understanding of the objects. Such integration contributes to reconstructing the 'chaîne opératoire' of the object and, in this way, the digital record helps reveal the forms of agency materialised in the artefact: the intentions, skills, and decisions of the individuals and communities involved in its creation. The diversity of the ITSERR datasets made it clear that 3D documentation does not respond to a single need. For some classes of material, such as fragile objects in glass for example, or artefacts kept in remote or high-risk locations, 3D models provide an essential surrogate when direct examination is limited. For other, more robust materials, however, the question becomes a different one: beyond ensuring accessibility, in what ways can 3D data actually enhance research and improve preservation?

This also highlights the limitations of purely technical or visually driven approaches, which often prioritise the production of digital replicas over the analytical questions they are meant to serve. Without a clear research framework, digitisation risks becoming an end in itself rather than a tool for understanding cultural heritage. 3D acquisition forces us to reconsider what should be documented, which features hold analytical significance, and how detailed a digital representation must be in order to support specific research questions, for example by making visible shallow surface modifications or fine incisions that are difficult to detect in 2D images. It also offers opportunities to visualise surfaces, manufacturing traces, wear patterns, and spatial arrangements, thereby contributing both to interpretation and to monitoring the state of preservation over time. These considerations make it clear that digitisation workflows must be designed in relation to specific research needs rather than applied uniformly.

3D geometry alone risks becoming an empty shell without contextual metadata. Archaeometric analyses are essential for understanding technological choices, raw-material sources, workshop practices, and object biographies. Seen in this light, digital documentation becomes far more than a technical exercise: it transforms the analytical landscape, expands the types of questions researchers can ask, and supports new forms of comparative, contextual, and interdisciplinary research. It is within this broader methodological framework that the case of the magic-therapeutic bowls must be understood.

3. Rethinking artefact analysis through 3D documentation: the case of the magic-therapeutic bowls

Within the ITSERR project, the Islamic magic-therapeutic bowls preserved at the Museo Orientale 'Umberto Scerrato' provided an ideal case study for testing the research potential of digital documentation. The corpus forms part of an important donation by Armando Tagliacozzo, owner of the Aron

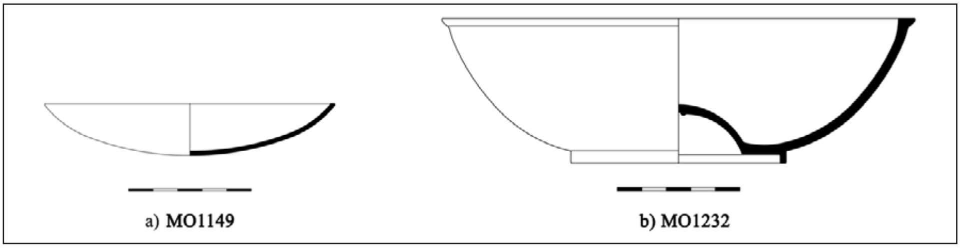

Fig. 1 – Evolution of the shape of magic bowls: a) MO1149, 12th-13th century hemispherical bowl; b) MO1232, 16th century bowl with hemispherical umbo (drawings C. Passaro).

Fig. 2 – MO1149 with highlighted details of the decoration (from Bernardini, Giunta 2025, 14; graphic elab. by A. Antonelli).

Collection, one of the most significant private collections of Islamic metalwork. The donation includes 105 metal bowls, 3 ceramic specimens, and 6 talismans, making it one of the most extensive assemblages of magic-therapeutic artefacts worldwide (Bernardini, Giunta 2025). Magic-therapeutic or, more simply, magic bowls are vessels primarily cast in bronze or brass alloys and produced across the Islamic world from the 8th to the 18th/19th centuries, with some later and even contemporary examples. Their earliest development can be traced to a Syro-Egyptian *milieu*, and it is in this same region that their manufacture reached its peak between the 12th and 13th centuries. Although their most characteristic forms belong to this Islamic-period tradition, their origins appear to be connected with earlier practices of earthenware bowls with inscriptions in Jewish Aramaic and Syriac (Savage-Smith 1997).

Two principal morphological types are attested (Fig. 1, see Bernardini, Giunta 2025). Early bowls are hemispherical vessels of small size, with straight rims and no base; from the 15th century onward, production increasingly favoured bowls standing on low foot, with a central boss (*umbo*) which could be hemispherical, conical, or flat, sometimes perforated or fitted with small figurines. Over time, forms change, and later examples may feature pierced rims intended to suspend the bowls or to attach rattling inscribed tags, a practice attested in the 17th century and later. The bowls were ritual instruments rather than utilitarian containers. As widely documented (Savage-Smith 1997; Giunta 2018; Bernardini, Giunta 2025), they were used in healing and protective practices: liquids such as water, oil, milk, or honey were poured into the vessel and believed to absorb the beneficial properties of the inscriptions and images; the liquid was then drunk or used in specific ways, and in some cases the bowl itself could be positioned near or over parts of the body, depending on the condition being treated. Their surfaces present exceptionally dense decorative and textual programmes (Fig. 2).

Inscriptions were mostly in Arabic, occasionally in Persian, and sometimes in pseudo-scripts and they include Koranic verses, invocations, therapeutic formulas, names, dates, references to religious and political authorities, instructions for use. Planetary characters and enigmatic letter sequences also occur as well as symbols such as magic squares or the Solomon seal. These textual elements interact with symbolic and figurative motifs such as scorpions, snakes, dogs, intertwined dragons, stars, zodiac signs, geometric and vegetal ornamentation. The arrangement of texts and images in registers, bands, medallions, and cartouches forms highly structured compositions in which meaning emerges from the interplay between script, iconography, and material support. Many engravings were enhanced using dark or whitish inlays resembling niello or similar pastes to increase visibility.

Because of this complexity, the corpus is relevant to a wide spectrum of disciplines such as history of Islamic art, for stylistic development and iconographic programmes; epigraphers, for scripts, formulas, graphic variability, and pseudo-writing; scholars of medicine and ritual practice, for therapeutic instructions and beliefs; historians of religion, for apotropaic and ritual dimensions, and archaeologists for alloys, production techniques, surface treatments, and residues. To address such diverse research perspectives, the bowls must be documented through several layers of metadata (textual, iconographic, technological, archaeometric), ensuring that their multiple dimensions can be analysed in an integrated manner.

In this regard, 3D documentation plays a crucial role. It captures the spatial organisation of inscriptions on curved surfaces, subtle variations in engraving depth, micro-traces of tools, and features relevant to reconstructing working sequences or identifying later re-engraving. When combined with annotation systems, 3D models allow inscriptions to be linked with transliterations, translations, commentary, and bibliographic references, thereby transforming the models into dynamic research instruments supporting comparative studies across collections and collaborative work among archaeologists, epigraphers, art historians, and historians of religion and medicine.

Only by combining 3D data with archaeological science and structured metadata is it possible to reconstruct the agency of these artefacts: the ways in which their materiality, inscriptions, iconography, and morphology actively shaped therapeutic and ritual practices. This integrated perspective allows the bowls to be understood not merely as inscribed metal vessels, but as complex cultural products whose meaning unfolds through their production, use, perception, and transmission.

A detailed description of the 3D acquisition strategy, together with the scanning, alignment, and photogrammetric processing workflow, is provided in the Technical Appendix, where the methodological challenges posed by the morphology and reflectivity of the bowls are discussed in depth.

4. Digital access, monitoring, and public engagement

Digital documentation does more than support research: it also contributes directly to preservation and expands the ways in which cultural heritage can be accessed and experienced. The work carried out within ITSERR has shown that 3D models are not simply visual surrogates but detailed records of the condition of an object at a specific point in time. Minute variations in engraving depth, tool marks, and small surface irregularities that may not be evident during direct examination become clearly visible in a digital environment, turning these models into valuable references for monitoring changes and informing conservation strategies. This potential is equally evident in the photogrammetric reconstruction of several Meroitic stelae recently destroyed, produced by G. Ferrandino in collaboration with F. Diara

(University of Torino, WP9). In this case, digital techniques made it possible to preserve the memory of objects that no longer exist, ensuring continued access for study and comparison.

The enriched 3D models of the magic-therapeutic bowls, complete with annotations, controlled-vocabulary tags, and structured metadata, further expand accessibility. They make inscriptions, decorative schemes, and morphological features available for close remote inspection, offering a level of detail that is often difficult to obtain from the originals, which are fragile or not easily handled. This digital environment supports interdisciplinary research, facilitates cross-collection comparison, and ensures long-term usability through adherence to FAIR principles.

These same digital resources also play a central role in public engagement. Animated 3D sequences, such as those created for the bowl MO1139, allow viewers to observe details that would be almost impossible to perceive in a display case, offering a clearer understanding of how inscriptions and motifs unfold across curved surfaces. Collaboration with the University of Torino has further enabled the production of high-quality 3D-printed replicas, which have proved valuable both for teaching and for inclusive museum practices. An example is the multisensory tour organised on 9 April 2025 for blind and visually impaired visitors, where tactile exploration of the printed replicas was combined with sound and scent to create an immersive experience that offered access to aspects of the bowls that would otherwise remain inaccessible.

Online access reinforces this dimension. The platform developed by C. Passaro (https://www.islamicmagicbowl.eu/) makes several 3D models of the bowls freely available, together with audio descriptions, teaching materials, and interactive tools. Designed according to universal-access principles, it supports screen-reader navigation, keyboard controls, adjustable zoom, and clear descriptive captions, allowing users with different needs and abilities to explore the objects in meaningful ways and at their own pace.

Beyond the material dimension of the bowls and their inscriptions, these artefacts also embody an intangible component linked to beliefs, ritual practices, and the symbolic frameworks that shaped their use. While such aspects are not directly observable in the digital record, immersive technologies like Virtual Reality can help evoke elements of this broader cultural context. Carefully designed VR environments may recreate plausible ritual settings or modes of interaction, allowing visitors to gain a sense of how the bowls might have been handled, perceived, or ‘activated’ within therapeutic or protective practices. Although these reconstructions do not and cannot provide historical certainty, they serve as effective interpretative tools, helping audiences understand the interplay between material and immaterial dimensions that characterise these artefacts.

Taken together, these developments demonstrate that digital access, monitoring, and public engagement are tightly interconnected. The same technologies that enhance research and preservation also enable new forms of participation and interpretation, making complex artefacts more accessible and opening broader pathways for understanding their cultural significance.

5. Conclusions

The research carried out within the ITSERR framework demonstrates how digital technologies, when combined with analytical methods, can actually transform the study of artefacts. The case of the magic-therapeutic bowls shows that 3D acquisition is not merely a form of visual reproduction but a tool capable of disclosing relationships between materiality, morphology, inscription layout, and iconography that would be difficult to perceive through traditional documentation alone.

A key outcome of the project is the recognition that digitisation is most effective when it operates as part of an integrated workflow. High-resolution 3D models, textual annotation, iconographic analysis, and technological investigation together enable a multi-layered reading of the objects. This synergy allows researchers to reconstruct the 'chaîne opératoire' of the artefacts, understand the technical choices behind their manufacture, and detect the forms of agency materialised in their surfaces. The digital replicas produced within ITSERR are therefore not passive surrogates but active research instruments. They can be interrogated, compared, annotated, and reused in multiple contexts, supporting collaboration between archaeologists, art historians, epigraphers, conservators, and museum professionals. Their interoperability is strengthened by the adoption of controlled vocabularies, structured metadata, and semantic models such as CIDOC-CRM, which facilitate long-term preservation and the integration of datasets across institutions.

At the same time, the project highlights the value of digital documentation for accessibility, preservation, and public engagement. Online platforms, interactive viewers, and high-resolution visualisations make complex artefacts available to non-specialist audiences, including users with visual or mobility impairments. The creation of 3D-printed replicas, which could be used in multisensory exhibitions and educational programmes, shows how digital outputs can enhance inclusive museography while protecting fragile originals. The photogrammetric reconstruction of the destroyed Meroitic *stelae* further illustrates how digital techniques can contribute to the recovery and valorisation of lost heritage.

Looking ahead, the experience of ITSERR underscores the importance of continuing to develop standardised, interoperable, and research-driven digitisation protocols, including the integration of archaeometric datasets that remain essential for fully understanding production technologies, material choices, and workshop organisation. The methodological model proposed here, grounded in technical accuracy, semantic clarity, and accessibility, provides a foundation for future initiatives in the digital documentation of religious and ritual material culture. It shows that digital humanities, when combined with archaeological science and metadata-rich environments, can meaningfully transform both the study and the dissemination of cultural heritage.

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APPENDIX: 3D ACQUISITION AND PROCESSING WORKFLOW: MULTI-PASS SCANNING, ALIGNMENT AND MESH PRODUCTION

The work carried out within the frame of ITSERR went beyond semantic investigation and, in order to support the study, the team acquired high-resolution 3D scans of the bowls, producing digital replicas that enable detailed, component-level analysis and allow researchers to investigate the relationships between material features, inscriptions, and iconography (Fig. 3). This has to be considered as a necessary step toward fully interoperable, analysable records of these complex objects. However, the acquisition process presented significant challenges because of the morphology of the bowls. Although the vessels are broadly concave in form, their interior and exterior surfaces often include convex elements such as bosses, reliefs, ornamental projections and undercuts that create occluded areas. As a result, complete capture cannot be achieved with a single pass: multiple scans from different angles are required, followed by careful alignment and merging.

This is particularly true for specimens with a deep base, where portions of the inner surface remain largely hidden in a single orientation. In such cases two sets of scans are performed, with the object rotated 180° between sessions. The interior and exterior are scanned and processed separately, making it essential to acquire common

Fig. 3 – High resolution digital twin of the magic-therapeutic bowl MO1139 (rendering by A. Antonelli).

connection points or overlapping features that allow the two datasets to be registered together. Due to the minimal thickness of the rim, it cannot be relied upon to merge the inner and outer surfaces, so registration must depend on other shared features.
Another problem arises from the material. The bowls are made of copper alloys and have a naturally shiny, reflective surface. Various strategies have been tested in an attempt to overcome the issue of reflectivity in shiny or metallic artefacts (Nicolae *et al.* 2014). One popular method is to coat the object in talcum or clay powder, which significantly improves the geometric accuracy of the reconstruction and the uniformity of the resulting mesh structures (Surmen 2025). However, approval from the relevant institution is not always granted for the application of such substances, as was the case with the magical-therapeutic bowls. A non-contact approach was adopted for the digitisation of the bowls. Both active (3D scanner) and passive (photogrammetry) data acquisition techniques were applied to define the most effective method for acquiring complex artefacts (Kai-Browne *et al.* 2016, 399).

Laser scanner

A selection of objects was scanned using a Creality Otter 3D laser scanner and processed with the proprietary software Creality Scan (Fig. 4). Given the good results previously achieved using the scanner especially with small size objects, this method was trialled to evaluate the effectiveness of laser scanning for complex small/medium size objects, such as concave/convex shapes and reflective metallic surfaces, which are known to present challenges in photogrammetric processing. The objects were placed on a fixed stand at an incline of approximately 45 degrees to record the overlapping points common to the outer and inner surfaces. Two sets of scans were acquired, one with markers on the surface and one without, to test the ability of the lens to recognise and capture details of the decorations.
As the scanner needed to be connected to a laptop via a cable throughout the process, it was preferable to scan the objects on a rotating plate. Various acquisitions combining the multiple scanning modes available through the Creality Scan software settings, were tested. However, the results were unsatisfactory. The scanner struggled to acquire complete geometry, particularly when merging the inner and outer surfaces, resulting in an incomplete or a misaligned model. Even when scanning the two separate surfaces, the software was unable to merge the two different point clouds together at the end of the acquisition. Furthermore, the textures generated were inconsistent and blurred due to the reflective nature of the metal. As a result, the scanner was ineffective because the artefacts were too complex in shape, lacking a continuity between inner and outer surface due to the thinness of the rim, and too reflective given their metallic composition.

Photogrammetry

Due to the limitations of the laser scanner, photogrammetry was adopted as the primary strategy. A Nikon D750 FX DSLR camera with a 24.3 MP full-frame sensor and a 24-120 mm f/4 lens was used to capture photographic images (Tab. 1). The camera was mounted on a tripod to allow for controlled exposure times. Image acquisition took place in the storage rooms of the Museo Orientale 'Umberto Scerrato', where the bowls are temporarily housed while awaiting the new exhibition setup scheduled for beginning 2026 (Fig. 5).

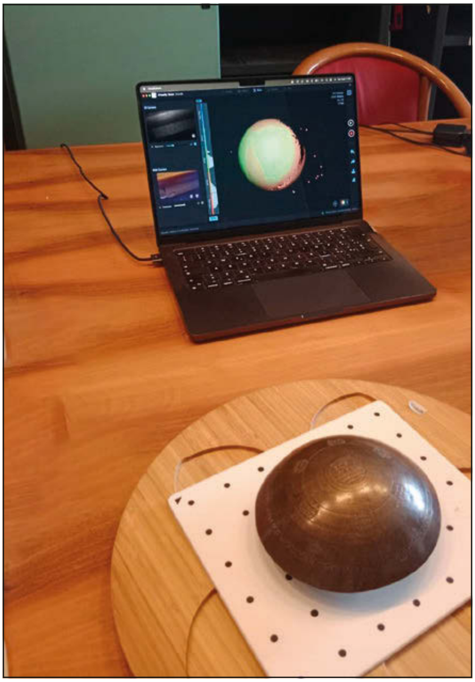

Fig. 4 – Acquisition with Creality Otter 3D laser scanner (A. Antonelli).

Fig. 5 – Acquisition for photogrammetry (A. Antonelli).

Resolution	6016 x 4016
DPI	300dpi
F-stop	F/11
Exposure time	1/4sec.
ISO	ISO-100
Focal distance	50cm

Tab. 1 – Characteristics of the acquired photographs.

Laser Scanner	**Photogrammetry**
Fast scanning	Long acquisition time
Fast processing time	Long processing time
Unable to merge inner and outer surface	Able to merge inner and outer surface through the identification of manually-selected shared control points
High geometric resolution (high accuracy up to 0.02mm)	High number of triangles/polygons
Inconsistent and blurred texture	High-definition texture

Tab. 2 – Laser scanning *vs* photogrammetry.

The artefacts were placed inside of a lightbox with a cold, diffuse, and evenly distributed light in order to eliminate harsh shadows and strong reflections, thereby improving image readability and facilitating accurate feature matching by the photogrammetry software (Hallot, Gill 2019, 130; Lanzara, Catello, Casciello 2022). Both uniform white and black backgrounds were tested and proved effective in minimising noise and unnecessary stray points during processing. The artefacts were placed on a turning table for digitisation. Two sets of scans were acquired: one for the interior and one for the exterior. For bowls with deeper bases, an additional scan of the inner surface was necessary, with the object rotated by 180 degrees. To ensure sufficient overlap between the two sets, the objects were fixed to stands at a 45-degree angle. In order to maintain a 60%-80% overlap between the images, the object was rotated by at least 1/16 of a full turn between shots. Despite the complex shape of the bowls, no physical markers were placed on the surface. Identifiable control points were used during processing to assist in aligning and merging the models instead.
Two different photogrammetric software packages were used for processing: Agisoft Metashape and the open-source RealityCapture. Metashape was unable to align a sufficient number of images for most of the objects. By contrast, RealityCapture proved more effective for alignment, 3D reconstruction, and texture rendering, and it offered both a step-by-step tutorial and online tutorials. Due to the differences between the selected artefacts, the processing was rather complex and different strategies had to be employed. The inner and outer surfaces were processed separately. After aligning the images and building the point clouds (Fig. 6), manual cleaning of unwanted stray points was often necessary. In some cases, particularly with smaller bowls, flatter objects, or when bulkier supports were used, it was necessary to mask the images to isolate the object and to remove background areas to improve alignment.

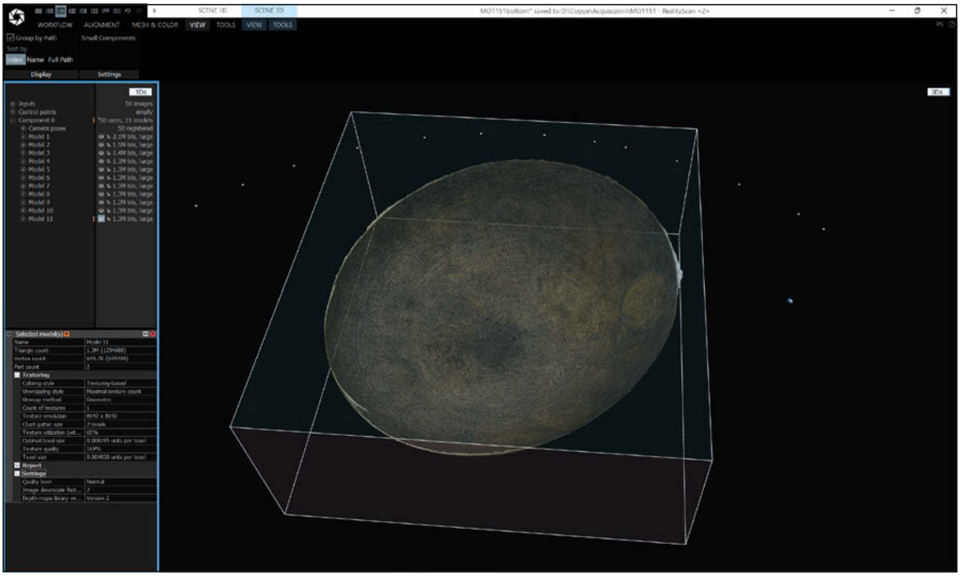

Fig. 6 – MO1152, point cloud generated after image alignment (processed by A. Antonelli).

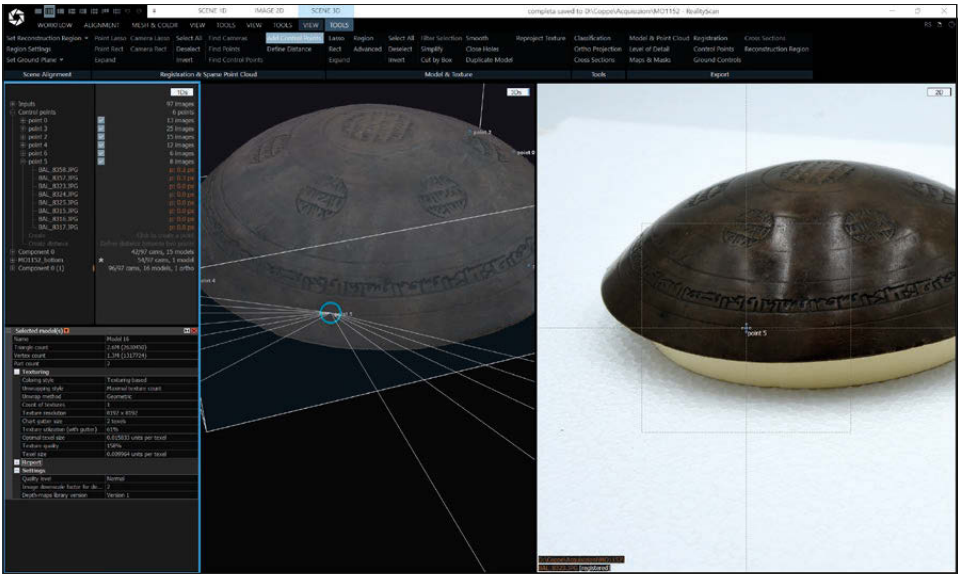

Fig. 7 – MO1152, placement of control points on the point cloud (processed by A. Antonelli).

Fig. 8 – MO1149, textured model a) top, b) elevation, c) section (A. Antonelli).

Masks could be obtained quickly thanks to the 'depth and mask' command in the RealityCapture export panel.

The two separate point clouds were imported into a new, single file, after which the shared control points were identified (Fig. 7). These are specific decorative details, inscriptions, decorative motifs, symbols or surface defects and anomalies visible in both sets, that appeared in both clouds. These control points are crucial for creating a unified model.

Based on the recognition of previously assigned control points, RealityCapture offers the possibility of merging the two point clouds through the 'merge components' process. This process is faster because the software processes components that have already been aligned, rather than realigning the entire set of images again.

After computing the final mesh, the integrity and the topology of the models were checked. In some cases, both an automatic and a manual cleaning of the model were necessary in order to eliminate non-manifold vertices/edges, holes, isolated vertices and stray points. The software was also effective in the texturing process, generating a high-definition texture that enabled the inscriptions and decorations on the surface to be read correctly (Fig. 8).

Various tests were conducted using the Creality Otter laser scanner and two photogrammetry software programmes. This enabled us to identify the strengths and weaknesses of the two methods and the equipment employed (Tab. 2). A brief comparison will now be provided to determine the most effective approach for creating digital twins of complex objects. The Creality Otter laser scanner allows scanning objects relatively quickly. Scanning and processing can be carried out easily using the Creality Scan software, which offers multiple scanning modes and settings. The process is fast and straightforward, and manuals and tutorials (written and video) can easily be accessed directly through the Creality website. The laser scanner can also acquire high-definition models with a geometric resolution of up to 0.02 mm. However, the laser scanner was ineffective when it came to merging the inner and

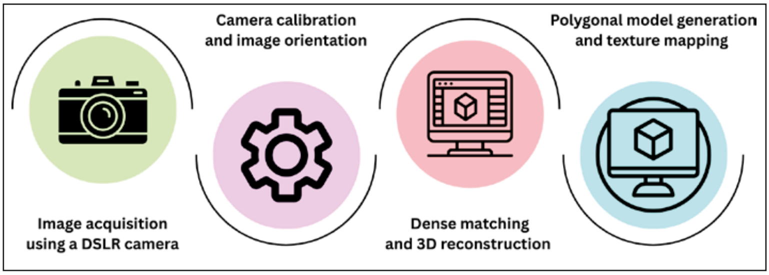

Fig. 9 – Workflow summary.

outer surfaces during scanning and processing due to the lack of continuity, resulting in a misaligned point cloud. Additionally, the laser scanner was ineffective in texturing due to the reflective, metallic surface of the bowls. Despite the high-resolution RGB camera, the resulting texture was inconsistent and blurred.

On the other hand, photogrammetry was effective in creating complete 3D models and high-resolution textures. However, acquiring and processing the models required a long and laborious process (Fig. 9). Depending on the morphological characteristics of the artefacts, 70-120 photographs were acquired for each object. The subsequent processing, including photograph alignment, control point selection, merging of components, mesh creation and texturing, also took from 40 minutes up to several hours for the most complex objects. However, photogrammetry has allowed us to obtain high resolution meshes, with a high number of triangles/polygons, up to 2.6M, as well as a high-definition texture (8192×8192).

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ABSTRACT

This article presents a methodological framework for the integrated digital documentation and analysis of inscribed artefacts in the context of cultural heritage research and collections. It focuses on the combined use of high-resolution 3D photogrammetry, structured metadata, and semantic annotation as tools for investigating objects whose significance lies at the intersection of materiality, text, and ritual practice. The approach is illustrated through a corpus of Islamic inscribed metal bowls preserved in the Museo Orientale 'Umberto Scerrato' in Naples, examined within the broader framework of the ITSERR project, dedicated to the study and digital representation of religious texts and their material transmission. Three-dimensional models are treated not as simple visual surrogates, but as analytical environments in which inscriptions, decorative elements, manufacturing traces, and spatial relationships can be systematically recorded, queried, and linked to textual and contextual information. The paper discusses data acquisition protocols, modelling strategies, and principles for organising interoperable datasets designed for long-term preservation and reuse. By integrating technological, philological, and archaeological perspectives, the proposed workflow contributes to current debates on digital methods in cultural heritage research and outlines practices that can be transferred to a wide range of inscribed objects and textual corpora beyond the specific case study.