

# Bernini's Tondo, a drawing depicting St. Joseph and Baby Jesus. A digitalizing method to increase knowledge and monitor cracks

Beatrice Calosso<sup>1</sup>, Marialuisa Mongelli<sup>2</sup>, Sara Pettisano<sup>3</sup>, Samuele Pierattini<sup>4</sup>

<sup>1</sup> ENEA, TERIN-ICT-HPC, Frascati Research Centre, Via E. Fermi, 45, 00044, Rome, Italy

<sup>2</sup> ENEA, Rome headquarters, Lungotevere Grande Ammiraglio Thaon di Revel, 76, 00196 Rome, Italy

<sup>3</sup> Pisa University, Department of Philology, Literature and Linguistics, Palazzo Matteucci, Piazza Evangelista Torricelli, 2, 56126 Pisa, Italy

<sup>4</sup> ENEA Firenze Territorial Office, c/o CNR - Via Madonna del Piano, 10 - 50019 Sesto Fiorentino, Italy

## ABSTRACT

The main goal of the study described in this paper, carried out by the ICT Laboratory of ENEA, has been to define a cognitive method of a drawing based on the Photogrammetry technique, applied with success on the Bernini's sanguine well known as Tondo Bernini. Crossing digitalized data with archival data, the method proved to be useful both to improve the knowledge of the artwork, and to define its conservation actual status, since it facilitates the medium and long-term monitoring of the damages that have been measured. With a very easy to find and use instruments, such as a photo camera and commercial software, images of the *Tondo* have been collected and then post-processed to create a three-dimensional virtual model: a tool that can help in fulfilling different goals with different audience. First, the method applied supports restorers in the conservation practices, allowing to see what is not evident to the naked eye, especially the smallest cracks on the surface. In parallel, the historians will analyze more in-depth the details highlighted by the 3D model, in order to show up further historical, material, and iconographic characteristics. Finally, it can foster a wider and deeper fruition by the public.

**Section:** RESEARCH PAPER

**Keywords:** Bernini; drawing; photogrammetry; 3D model

**Citation:** B. Calosso, M. Mongelli, S. Pettisano, S. Pierattini, Bernini's Tondo, a drawing depicting St. Joseph and Baby Jesus. A digitalizing method to increase knowledge and monitor cracks, Acta IMEKO, vol. 14 (2025) no. 1, pp. 1-7. DOI: [10.21014/actaimeko.v14i1.1881](https://doi.org/10.21014/actaimeko.v14i1.1881)

**Section Editor:** Fabio Leccese, Università Degli Studi Roma Tre, Rome, Italy

**Received** May 20, 2024; **In final form** December 24, 2024; **Published** March 2025

**Copyright:** This is an open-access article distributed under the terms of the Creative Commons Attribution 3.0 License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

**Funding:** This work was supported by the Lazio Region, through the Technological District for Cultural Heritage – DTC.

**Corresponding author:** Beatrice Calosso, e-mail: [beatrice.calosso@enea.it](mailto:beatrice.calosso@enea.it)

## 1. INTRODUCTION

The state of conservation of ancient artworks can be monitored quickly and inexpensively by using Photogrammetry, a consolidated and effective technique, that can also be useful for conservators and historians [1]. Comparing the difficulty of accessing some artworks with other larger tools powered by electricity, Photogrammetry can be applied more easily in numerous and different type of locations, not only museums but also crypts and inhospitable spaces [2]. Moreover, the openness of software for post-processing and analysing images is another benefit to opting for this technique.

Despite of all these advantages, Photogrammetry has rarely been used as a tool to investigate, describe and communicate

ancient drawings with artistic and historical value, and to better understand their methods and contents. However, in the very few but prestigious interventions of this type, such as the study of Leonardo's drawings [3], it has proved to be a valuable tool for faithfully reproducing shape, characters and appearance, as well as for highlighting any damage sometimes little or nothing visible to the naked eye. Considering all these benefits that come with the use of this technique, the ENEA ICT Laboratory for Cultural Heritage has chosen to use it to investigate the state of conservation of Bernini's Tondo: a really rare wall sanguine drawing, attributed to Gian Lorenzo Bernini [4] due to the fact that it is among the few artworks signed by the artist [5].

By employing the Structure for Motion technique (SfM) the digitalization of this drawing was achieved, to create a 3D



Figure 1. The drawing 'Tondo' by Gian Lorenzo Bernini.

reconstruction, which will enhance the knowledge and fruition of the sanguine throughout a larger audience, that in the future will be able to access the artwork, even on the Web, thanks to the 3D model made by the ENEA ICT lab.

Specifically, this paper describes the results obtained in the photogrammetric campaign that was executed (in the year 2019) within the ADAMO Project [6], financed by the Lazio Region, through the Technological District for Cultural Heritage – DTC [7]. Thanks to the project, a series of diagnostic surveys was performed by Latium Research Institutes and Universities, with

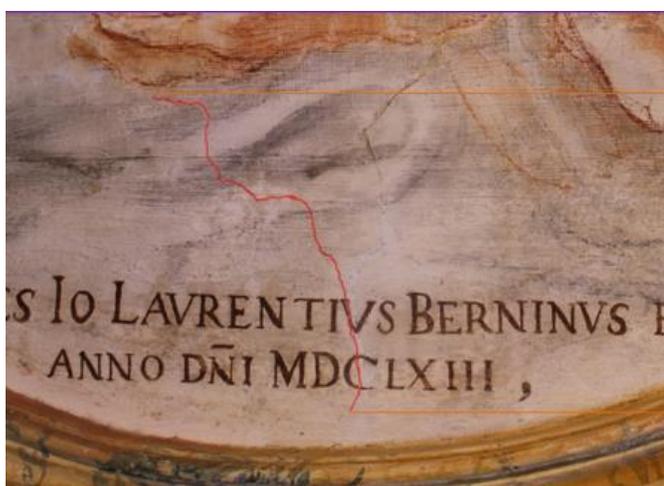


Figure 2. Detail of the inscription with a highlighted lesion (the red line).

the common aim of enhance the knowledge and improve the preservation of some selected artworks distributed in the Lazio Region. The added value coming from ADAMO Project is the integration of different sophisticated non-destructive and non-invasive technologies and methodologies that have allowed to obtain complex and complete results about the state of conservation, the materials, and the techniques of execution of numerous sculptures, paintings, architectures, archaeological sites, etc.

As one of the partners of both DTC and ADAMO, the ICT ENEA Lab has employed specific tools (digital and not) to help preserving ancient artifacts, both pictorial and sculptural, housed in the Chigi Palace in Ariccia, seat of Baroque Museum, including the Bernini's Tondo [8].

## 2. THE ARTWORK

The Bernini's drawing (Figure 1), dated 1663, is located on a wall in a very small private chapel on the first floor of the main Palace in Ariccia (a village near Rome), residence of the Chigi family, one of the most powerful dynasties of that period. The second half of the Seventeenth Century saw Bernini working there for the Chigi family and especially for Pope Alexander VII [9].

The Tondo depicts Saint Joseph with the Child Jesus and measures 1.11 m by 1.10 m. The technique of realization is the sanguine, often used by painters for sketches and preparatory drawings, afterwards covered by paint. The autograph would seem to be demonstrated both by the inscription «EQUES IO LAURENTIVS BERNINI FAC: ANNO DNI MDCLXIII,» (Figure 2) which means «Me Cavaliere Bernini done: Anno Domini 1663», that can be read inside the Tondo, and by the comparison with another autograph drawing of the artist, depicting the same iconographic theme, today preserved in the Chigi Archive of the Vatican Apostolic Library [10]. The frame that surrounds the artwork is dated 1771 and it was painted as fake marble by Luigi Baldi and commissioned by Sigismondo Chigi [11].

The drawing was described for the first time by Stanislao Frascchetti to be "very curious for its originality" [12]; in fact, to find Saint Joseph and the Child in such pose must be considered a rarity with very few precedents, particularly before the Counter-Reformation.

### 2.1. The iconography

The representation of Joseph alone (without Mary) with the Baby Jesus in his arms spread internationally from the late Seventeenth-early Eighteenth century, when the autonomous cult of the Saint intensified. In fact, in this period his image acquired a lot of popularity, embodying the ideals and the role of the *pater familias*, to whom the Catholic education of children is entrusted [13].

For this reason, the figure of the Saint become autonomous from the presence of the Virgin Mary and started having a more intimate connection with the Holy Baby, such as in two paintings by Guido Reni: *St. Joseph and the Baby Jesus* (1625-30), conserved in the Diocesan Museum in Milan, and *St. Joseph with the Infant Jesus* (1640), exhibited in the Houston Museum of Fine Arts. In these two paintings the iconography is almost the same of the Tondo: in fact, the Baby is hold by the old father who is looking directly in his eyes [14].

According to the foremost expert of the Tondo, Francesco Petrucci (art historian and director of the Baroque Museum located in Palazzo Chigi), Bernini's choice of this iconography would be related to the birth of Augusto Chigi, the first son of Agostino Chigi, who could be both symbolically represented in the sacred scene, portrayed in a gesture of great humanity and naturalness, according to the traditional iconography but also to the privacy of the chapel [15].

The profile of St. Joseph reveals evident affinities with another Bernini's artwork, the 'Portrait of frate cappuccino' [16]; but, at the same time, a recent comparison made tanks to this survey, makes evident also another remarkable similarity with the Agostino Chigi portrait, sculpted in marble by the same artist (Figure 3) in 1652 for his sepulchre, inside a chapel into the Basilica of Santa Maria del Popolo in Rome [17].



Figure 3. Portrait of Agostino Chigi (marble relief) compared to the profile of St. Joseph in the Tondo.

## 2.2. The framework

The round shape of the sanguine is not common for the represented subject. In fact, since the Renaissance, this kind of framework was used more commonly to contain scenes of the Holy Family and Motherhood. Traditionally, circular shape is related to the 'Birth Chart', a gift to either new mothers or brides, to wish good luck [18]. Bernini instead uses it with a certain frequency to contain the dead's portrait sculpted on tombs, that seems more related to the traditional iconography of saints and prophets. Looking for some precedents, in the Italian National Catalogue of Artworks [19] similar subjects inside a rounded framework weren't found, whereas both in frescos [20] and canvases [21] seem to be quite common, even though enclosed in an oval shaped medallion and sometimes painted as an architectural *trompe d'oeil* element.

Based on these observations it could be possible to hypothesize that the round shape of the sanguine initially may have had a different purpose, such as to contain a portrait of a deceased member of the Chigi family. Otherwise, it could be that the initial shape was different, and that it was changed afterwards, when the framework was added to contain the drawing.

## 3. PREVIOUS SURVEYS AND STUDIES ON THE TONDO

In 2019 and 2020, during the ADAMO Project, the University Roma Tre in collaboration with The National Institute for Nuclear Physics (INFN) applied a combination of tools - X-ray Fluorescence (XRF), Laser-induced fluorescence (LIF) and Raman and Infrared vibrational spectroscopies (FT-IR) - to gather data on the chemical composition of the pigments used by Bernini to make both the sanguine mark and the *chiaroscuro*; also the background preparation material has been detected with the same technologies [22]. The dating of the elements discovered in the background suggests that the 'signature' could have been added after the realization of the Tondo, which might suggest that it was not written by Bernini himself [23].

Because of the drawing was object of a conservative intervention (on the occasion of the exhibition "L'Arccia del Bernini" in the 1998 [15]) also the conservation state of the materials used in these restoration treatments has been analysed by Ultraviolet-Visible Spectroscopy imaging analysis (UV-VIS). As already documented in the restoration schedules, conservative treatments involved filling some cracks on the Tondo surface. Some of these cracks were caused by the opening of a window underneath the artwork, which was closed during the restoration to avoid further damages [24].

During another survey led by the Laboratory of Non-Destructive and Environmental Analysis for Cultural Heritage of the Department of Industrial Engineering of the University of Rome Tor Vergata (LANDAC), Thermogram and Reflectogram techniques were applied to map the structural conditions of the sanguine. In this survey, also a grouting - perhaps a sign of the restoration work - was shown, along with numerous holes [25]. In this context, the photogrammetric campaign carried out by the ENEA ICT laboratory has aimed at measuring accurately the dimensions of all the cracks and damages, partially pointed out by the previous surveys, to better monitoring them and preventing any future deterioration.

According to Petrucci's studies, the execution of the artwork was carried out impromptu, without a preparatory drawing [11]. However, both the XRF and LIF, and even the recent thermographic campaigns [25] (conducted during the ADAMO Project) revealed a graphite section below the sanguine line,

exactly in the middle of the child's face, which should attest the existence of a preparatory sketch. Presumably, the sanguine, as usual in Bernini's paintings, was the trace for a fresco, which suggests that the Tondo could be unfinished, presumably because of the artist's trip to France or maybe caused by the death of his patron Pope Alexander VII Chigi [26]. In fact, the Pope had commissioned numerous works to Bernini, including the reconstruction of the Ariccia Baronial Palace, overlooking the renovated Court Square, but also the projects of numerous buildings in all the town, such as the Collegiate Church of the Assumption and the Sanctuary of Galloro [27]. In fact, when the artist was drawing the Tondo, he was also working on the Alessandrine Roads, with the aim of connecting the neighbouring countryside to the village and, in the same years, he was committed to the first intervention on the urban planning of Ariccia (1661-1663) [28].

#### 4. THE PHOTOGRAMMETRIC CAMPAIGN

In 2019 a photogrammetric campaign on the Tondo was conducted by a group of experts from the ENEA ICT Laboratory dedicated to Cultural Heritage, to classify any damage, crack, or weakness detected on the surface, so that future measurement campaigns, even conducted by the same staff of the museum, can continue monitoring them over time. As a documentation technique more commonly applied to capture the geometry of archaeological sites, monuments and architectures, using photogrammetry to record the fine surface details of a wall drawing requires specific plan [29]. First, during the photogrammetric campaign, a group of 136 images of  $5184 \times 3456$  pixels and 6MB each was taken. Then, these photos were postprocessed with the software Agisoft Photoscan Pro 1.4.5, following the workflow from the alignment of the individual photos to the return of the texturized 3D model in

high resolution. The point-cloud obtained in the post-processing phase is made of about 8 million and 500 thousand points and has been edited and cleaned using MeshLab, a software which allowed to redefine graphically the edges of the Tondo where they appeared irregular. Thanks to MeshLab the model has been also made lighter, reducing the number of points and surfaces, but without affecting the final quality of the texture. MeshLab served also to rotate the model to align it with the main axis; then the same software was used to select the parts of the wall that were of some interest and delete the spots and lees useless. The measurement of real dimensions was made easier by straightening the cloud in the digital model afterwards. Finally, the digital twin was superimposed with a grid created using the function brush of Photoshop. This grid has proved to be advantageous also in mapping injuries, tagged on the surface of artifacts with red lines.

##### 4.1. The 3D Model

Starting from the two-dimensional images, in the last phase, a 3D model (Figure 4) has been created using the Structure from Motion technique (SfM) [30]. This technique integrates photogrammetry with a specific software - Agisoft Photoscan Pro 1.4.5 - that automatically solves algorithms.

The SfM uses normal photographic images, in which reference points are identified thanks to their different lighting and perspective conditions. Afterwards, these points are collected in a dedicated database. Then, the images are grouped according to common points and from these are self-calibrated, creating a scattered cloud of points. The next step is the creation of a dense point cloud with colour values associated, extracted from the photo linked to each point. In fact, the dot cloud was created from photos reworked using Photoscan, from this dot cloud - first scattered, then dense - the mesh and finally the texture were created.

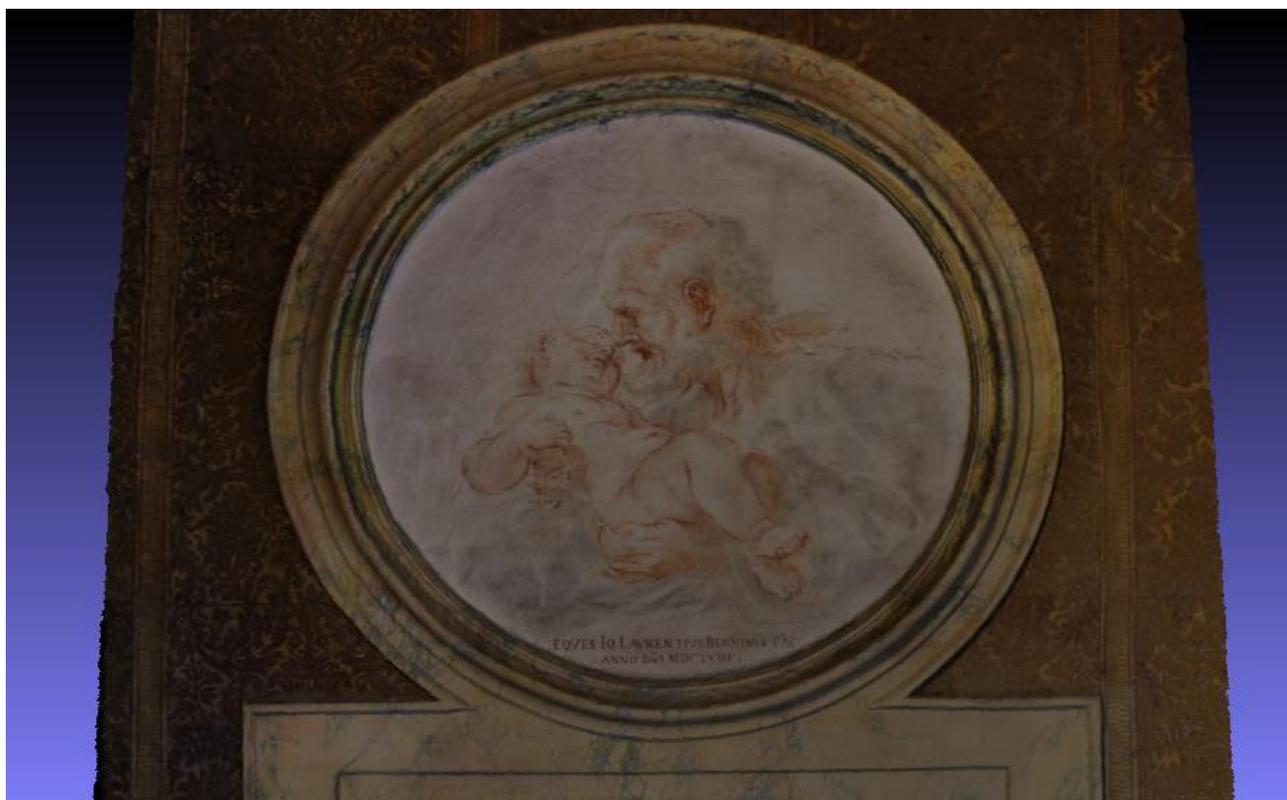


Figure 4. An image of the 3D model developed.

Finally, the texturized model shaped allows the projection of the photographs on the polygonal model. To realize this type of models also an amateur camera can be used, if first it has been calibrated. In fact, one of the main objectives of our 3D model is to assist restorers in possible future conservative intervention on the drawing; moreover, it can help historians and experts in their research to improve the knowledge on the artwork, supporting, for example, the vision of details (i.e. about iconography, feasant, etc.) not easy to detect by naked eye.

All the results obtained - images, numerical data, and the 3D model - has been stored in the virtual lab IT@CHA [31] set for the Cultural Heritage, hosted in the integrated computational infrastructure ENEAGRID [32] managed by ICT ENEA Laboratory, which allowed, on one hand, the access to the software resources, useful for post-processing photogrammetric data and for the SfM technique; on the other hand, in this infrastructure the results of the survey campaign are stored in a completely safe way, into a dedicated area reserved only to authorized users [33]. This area would continue to be used in the future to compare data from previous campaigns with the more recent data, that will be archived in the same data base, to facilitate monitoring the possible change of the lesions identified.

#### 4.2. The lesions measured

On the Tondo surface several lesions have been identified with varying levels of risk (Figure 5): from those of very small extension (about 0.002 m), to others much more dangerous (from 0.05 m to 0.09 m) that have a short-term worsening already foreseeable.

Going into detail, the investigation revealed seven main damage zones identified in Figure 6 and Table 1 in by using alphabet letters:

- A. a series of three small cracks of about 0.002 m, at the bottom of the Tondo, below the flank of the Child;
- B. a series of four damages on the trunk and on the belly of the Baby, of average extension about 0,015 m;

- C. another extensive lesion on Joseph's beard is about 0.034 m;
- D. a very extensive damage that begins in the lower portion of the framework and passes on the letters "C" and "U" of the inscription, that is almost 0.2 m long;
- E. Another one is extended on the right thigh of the Child of almost 0.05 m and with a possible future extension of 0.04 m;
- F. one damage is on the right foot of the Child, starting from a toe and rising with bifurcation along the ankle with an overall extension of 0,09 m;
- G. a not very extensive damage on the top of the left foot of the Baby is about 0.009 m maximum [34].

#### 5. THE RESULTS

One of the more relevant objectives achieved by our survey is the fact that the museum's staff will be able to easily replicate in the future the same method of investigation successfully applied in our photogrammetric campaign. The current conservation state of the sanguine, fixed within both the pictures and the 3D model of Bernini's Tondo, would be periodically supervised through the employment of the photogrammetric technique. In fact, the method that has permitted to identify each damage also displayed on a slide with a picture of a specific part of the drawing, will make easier to analyse in a deeper way, even remotely on the virtual lab IT@CHA, the state of conservation of the artwork. In addition, the grid that overlaps each image enables measurement of the single crack, reported in a table with the size of all the damages detected in meters.

Conservators and experts at the museum will need just a standard photo camera to capture measures that can be compared to previous ones, uploaded into the dedicated section of the virtual lab IT@CHA, even without the aid of external experts and complex technology. This method also avoids processing

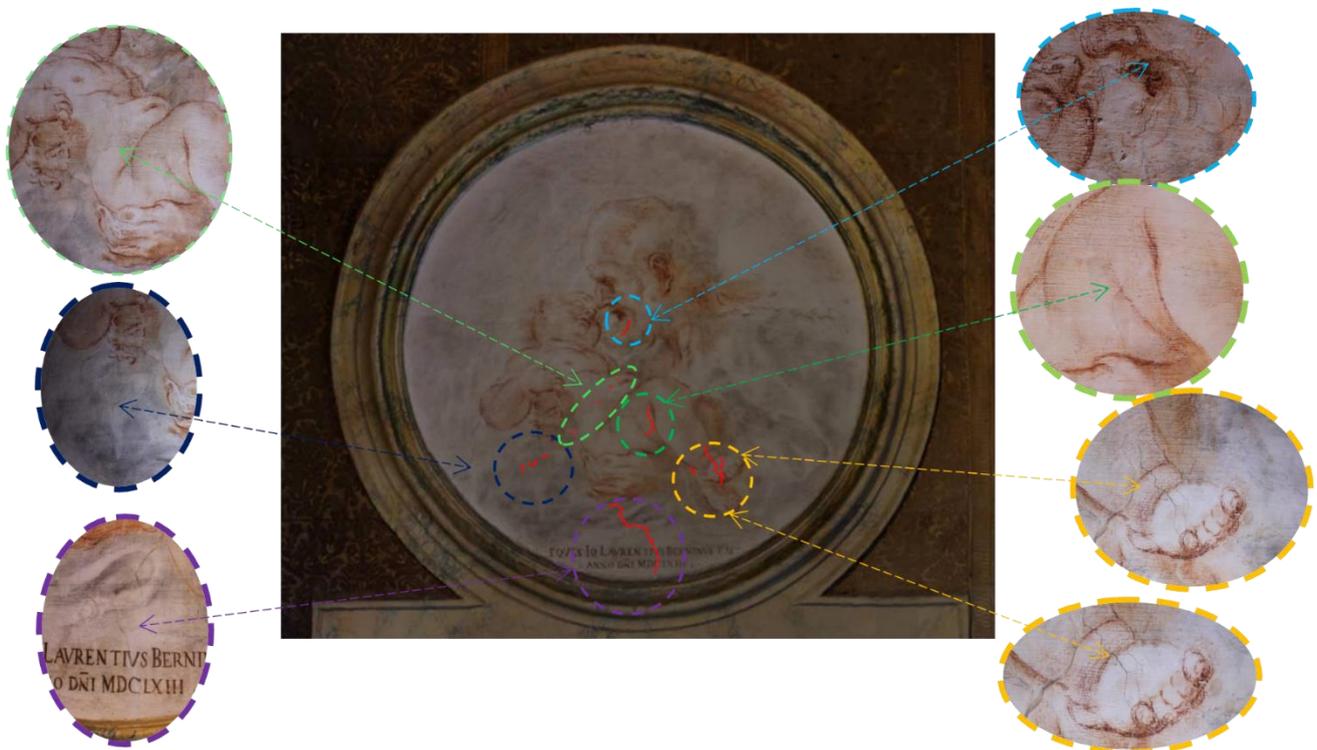


Figure 5. Lesions identified on the Tondo surface.

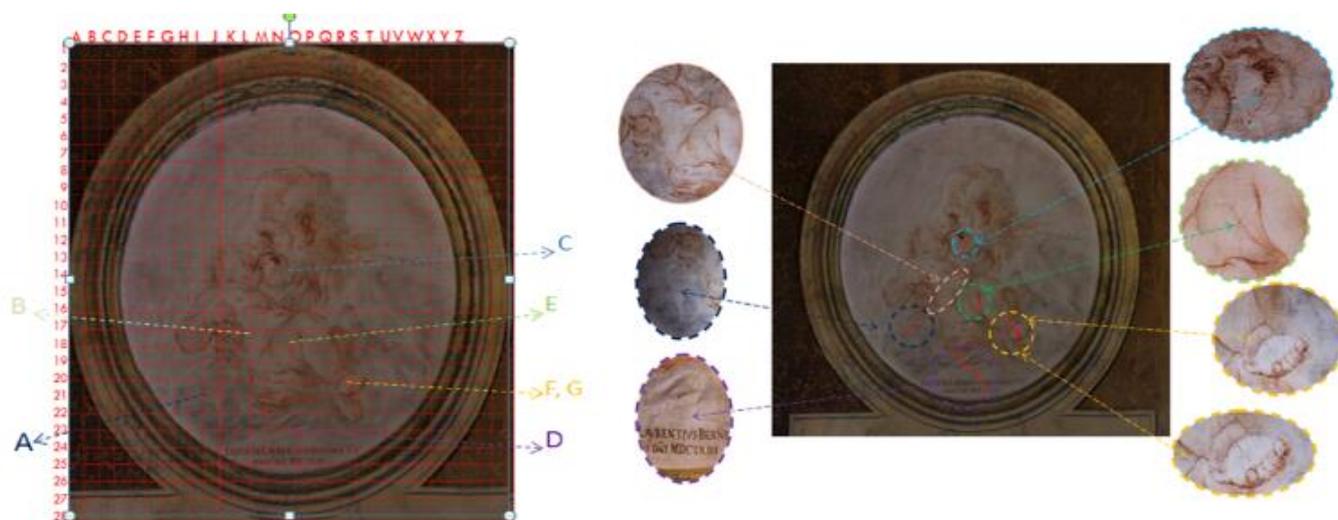


Figure 6. Lesions identified and measured by using an overlapped grid on the 3D model. These data have been collected in Table 1.

Table 1. Data for Figure 6.

A1	A2	A3	B1	B2	B3	B4	C	D	E1	E2	F1	F2	F3	G1	G2
J21	K21	J21	O17	O17	N18	L19	N14	O23, O24, P24, P25	P18	O19	S21	R20, S20	S20	R21	R21
0.029	0.013	0.018	0.008	0.004	0.012	0.021	0.034	0.195	0.046	0.04	0.05	0.083	0.01	0.02	0.09

quantities of data that would require too many economic and time-consuming efforts for the majority of Italian cultural sites.

Furthermore, a multimedia project to promote the various artworks and artifacts collected into the Chigi Palace's collection, along with the architectural site, could be carried out through the production of other digital twins, applying the same method used to create the 3D model of the Tondo. This virtual collection would be reproduced both on screens inside the museum, for a deeper three-dimensional vision, and on website for a remote fruition [35]. These 3D models will make enjoyable to a wider audience, even artworks and sites that are in conditions of limited accessibility, reducing the risk of damage [36].

## 6. CONCLUSIONS

The ENEA ICT laboratory's photogrammetric campaign at Ariccia Museum, resulted in a twice-beneficial outcome: firstly, easily acquiring numerical data on the current conservation status of the Bernini's sanguine; secondly, fostering knowledge and fruition of this artwork, through the three-dimensional digital twin created by the same team of researchers and experts.

All the activities have been made possible due to the ENEA-GRID infrastructure, in which the virtual lab IT@CHA is hosted. This virtual lab is specifically dedicated to Cultural Heritage and makes available - both for scientific and cultural institutions - hardware and software resources, effective at analysing data and creating digital 3D models of architectural monuments, paintings and sculptures. Moreover, data and 3D models are stored in total security into the ENEA-GRID infrastructure, which means that the information collected about an artwork will remain accessible to researchers and conservators.

The survey reported in this paper shows the effectiveness and the repeatability of the method applied in other similar cultural sites, but even where artworks are located in inaccessible

condition, when the human presence could cause risks for the conservation, or where other more complex tools and technologies cannot work.

The digitisation of Cultural Heritage and the management of the resulting data is recognised as one of the pillars of the development of digital and cultural transformation in Europe. For this reason, our campaign is in line with the European Commission Recommendation of 10 November 2021 [37] on the creation of a common European data area for Cultural Heritage. From this point of view, it is also important to point out that improving the quality of tools and methods for the digital preservation across the EU will ensure a significant impact also in other key areas, such as tourism, scientific research, and creative industries [38].

## ACKNOWLEDGEMENT

We would like to acknowledge the significant contribution made by the numerous studies and research conducted by the architect and historian Francesco Petrucci in several years of commitment to Palazzo Chigi and the Baroque Museum in Ariccia, of which is also the curator.

We would also like to thank the funding received from the Lazio Region through two projects - ADAMO and ECODIGIT - as parts of the DTC Lazio, whose financial support made our activities possible.

## REFERENCES

- [1] H. M. Yılmaz, M. Yakar, S. A. Gulec, O. N. Dulgerler, Importance of digital close-range photogrammetry in documentation of cultural heritage, *Journal of Cultural Heritage*, Vol. 8, (2007), pp. 428-433.  
DOI: [10.1016/j.culher.2007.07.004](https://doi.org/10.1016/j.culher.2007.07.004)
- [2] M. Mongelli, I. Bellagamba, G. Bracco, S. Migliori, A. Perozziello, S. Pierattini, A. Quintiliani, B. Mazzei, 3D photogrammetric

- reconstruction by “Structure from Motion” as a monitoring technique for safety, conservation and improvement of the fruition of cultural heritage, IMEKO Int. Conf. on Metrology for Archaeology and Cultural Heritage, Lecce, Italy, 23-25 October 2017. Online [Accessed 28 August 2024] <https://www.imeko.org/publications/tc4-Archaeo-2017/IMEKO-TC4-ARCHAEO-2017-044.pdf>
- [3] M. Gaiani, F. I. Apollonio, G. Bacci, A. Ballabeni, M. Bozzola, R. Foschi, R. Palermo, Vedere dentro i disegni. Un sistema per analizzare, conservare, comprendere, comunicare i disegni di Leonardo, in Leonardo da Vinci. Alle origini del genio, Giunti Editore, 2019, pp. 207-239. [in Italian]
- [4] V. Martinelli, Gian Lorenzo Bernini, in: Enciclopedia Universale dell'Arte, II, ed. Sansoni, Firenze 1959, col. 535, tav. XXXIX. [in Italian]
- [5] F. Petrucci, Considerazioni sulla sanguigna del Bernini nella cappella del Palazzo Chigi di Ariccia, Castelli Romani, monographic issue of the magazine Echi del Barocco xxxv (1995), pp. 120-25. [in Italian]
- [6] ENEA, Progetto ADAMO. Online [Accessed 28 August 2024] <https://progettoadamo.enea.it/english/>
- [7] DTC Lazio: Cultural Heritage and Activities Technology District. Online [Accessed 28 August 2024] <https://dtclazio.it/>
- [8] Palazzo Chigi di Ariccia. Online [Accessed 28 August 2024] <https://www.palazzo-chigi-ariccia.it/>
- [9] R. Lefevre, Il Bernini ad Ariccia e la Piazza di Corte dei Chigi, Te Roma Sequor, Quaderni di Storia e d'Arte (1981) 1 Roma. [in Italian]
- [10] F. Petrucci, Dipinti del Barocco romano da Palazzo Chigi in Ariccia, Gangemi, Roma, 2012. [in Italian]
- [11] F. Petrucci, Bernini pittore: dal disegno al meraviglioso composto, Ugo Bozzi, Roma, 2006. [in Italian]
- [12] S. Frascchetti, il Bernini: la sua vita, la sua opera, il suo tempo, U. Hoepli, Milano 1900, pp. 234 – 235. [in Italian]
- [13] Art Advisor. [in Italian] Online [Accessed 28 August 2024] <https://artadvisor.art.blog/2021/03/21/san-giuseppe-evoluzione-del-culto-e-dell'iconografia/>
- [14] S. Simoni, San Giuseppe. Iconografie di un padre fra cura e affetto, in, Ambiguo paterno, E. Morgagni, I. Morini (editors), Fernandel, 2017, p.29. [in Italian]
- [15] F. Petrucci, Bernini, Fabio Chigi ed Ariccia: un Rinascimento barocco, in Catalogo della mostra L'Ariccia del Bernini, M. Fagiolo dell'Arco, F. Petrucci (editors), Edizioni De Luca, Ariccia, 1998, p. 17. [in Italian]
- [16] A. Angelini, Un ritratto 'familiare' dipinto da Gian Lorenzo Bernini (con una nota sulle relazioni dell'artista con la pittura), Prospettiva (2005) 117/118, pp. 165-172. [in Italian]
- [17] J. Shearman, The Chigi Chapel in S. Maria del Popolo, Journal of the Warburg and Courtauld Institutes 24 (1961) 3-4, pp. 129-160.
- [18] C. De Carli Sciume, I “deschi da parto” e la pittura del primo rinascimento toscano, Allemandi, Torino, 1997. [in Italian]
- [19] Catalogo dei Beni Culturali. [in Italian] Online [Accessed 28 August 2024] <https://catalogo.beniculturali.it/>
- [20] Anonymous, Saint Joseph with the Child Jesus, from Tuscany, tempera on plaster, 18<sup>th</sup> Century. Online [Accessed 28 August 2024] <https://catalogo.beniculturali.it/detail/HistoricOrArtisticProperty/0900155070A-14>
- [21] Anonymous, Saint Joseph with the Child, oil painting on canvas, Italian northern centre, first half of the 18<sup>th</sup> Century. Online [Accessed 28 August 2024] <https://catalogo.beniculturali.it/detail/HistoricOrArtisticProperty/0100399746>
- [22] ENEA, Progetto Adamo. Online [Accessed 28 August 2024] [https://progettoadamo.enea.it/wp-content/uploads/2019/11/Sanguigna\\_Sbroscia\\_cut.pdf](https://progettoadamo.enea.it/wp-content/uploads/2019/11/Sanguigna_Sbroscia_cut.pdf)
- [23] M. Romani, L. Pronti, M. Sbroscia, F. Petrucci, O. Tarquini (+ 7 more authors), *S. Joseph with the Child* by Gian Lorenzo Bernini: A definitive artwork or a preparatory drawing? A multidisciplinary study of the only autograph painting of the Artist, preserved at Palazzo Chigi of Ariccia (Rome), Journal of Cultural Heritage 46 (2020), pp. 283-288. DOI: [10.1016/j.culher.2020.08.003](https://doi.org/10.1016/j.culher.2020.08.003)
- [24] D. Petrucci, F. Petrucci, Palazzo Chigi in Ariccia, guida illustrata, Gangemi, Ariccia, 2010. [in Italian]
- [25] S. Ceccarelli, N. Orazi, F. Mercuri, S. Paoloni, U. Zammit, F. Petrucci, Thermographic and reflectographic imaging investigations on Baroque paintings preserved at the Chigi Palace in Ariccia, Acta IMEKO 10 (2021), 1, pp. 187 – 192. DOI: [10.21014/acta\\_imeko.v10i1.828](https://doi.org/10.21014/acta_imeko.v10i1.828)
- [26] F. Baldinucci, Vita del cavaliere Gio. Lorenzo Bernino scultore, architetto, e pittore, Stamperia di Vicenzio Vangelisti, Firenze, 1682. [in Italian]
- [27] R. Lefevre, Sulla Costruzione del Palazzo Chigi già Savelli, in Lunario Romano XX (1991) Roma, pp. 193-212. [in Italian]
- [28] F. Petrucci, Il Palazzo Chigi di Ariccia, Ariccia, 1998, pp.17-42. [in Italian]
- [29] E. Ippoliti, A. Meschini, F. Sicuranza, Digital Photogrammetry and Structure from Motion for Architectural Heritage, comparison and integration between procedures. In Handbook of Research on Emerging Digital Tools for Architectural Surveying, Modelling, and Representation IGI Global, 2015, pp. 124-181. DOI: [10.4018/978-1-4666-8379-2.ch004](https://doi.org/10.4018/978-1-4666-8379-2.ch004)
- [30] L. Wong, W. Rose, A. Dhand, A. Flavin, L. Barazzetti, C. Ouimet, M. Santana Quintero, Maximizing the Value of Photogrammetric Surveys in the Conservation of Wall Paintings, in The Int. Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 2021, 46, pp. 851-857. DOI: [10.5194/isprs-archives-XLVI-M-1-2021-851-2021](https://doi.org/10.5194/isprs-archives-XLVI-M-1-2021-851-2021)
- [31] ENEA, IT@CHA Virtual Lab. Online [Accessed 28 August 2024] <http://www.laboratorivirtuali.enea.it/it/prime-pagine/it-cha-virtual-lab>
- [32] ENEA, ENEA GRID. Online [Accessed 28 August 2024] <https://www.eneagrid.enea.it/>
- [33] M. Mongelli, B. Calosso, S. Pierattini, M. Puccini, G. Ponti, The IT@CHA Virtual Lab: a set of enabling technologies for Digital Twin Implementation and Enrichment in Cultural Heritage, Proc. of the Conferenza GARR 2023 Saperi interconnessi - Infrastrutture per una scienza ad alte prestazioni, Florence, Italy, 14-16 June 2023, ISBN 978-88-946629-2-4, pp 30-38. DOI [10.26314/GARR-Conf23-proceedings-04](https://doi.org/10.26314/GARR-Conf23-proceedings-04)
- [34] S. Pettisano, Il Tondo di San Giuseppe ed il Bambino di Gian Lorenzo Bernini in Palazzo Chigi ad Ariccia, Bollettino Telematico dell'Arte, 2022, n. 928. [in Italian] Online [Accessed 28 August 2024] <http://www.bta.it/txt/a0/09/bta00928.html>
- [35] J. McCarthy, Multi-image Photogrammetry as a Practical tool for Cultural Heritage Survey and Community Engagement, Journal of Archaeological Science, 2014, 43, pp. 175-185. DOI: [10.1016/j.jas.2014.01.010](https://doi.org/10.1016/j.jas.2014.01.010)
- [36] L. Wolfram, N. Baloian, D. Biella, D. Sacher, Digital Twins and Enabling Technologies in Museums and Cultural Heritage: An Overview, Sensors 23, no. 3: 1583. DOI: [10.3390/s23031583](https://doi.org/10.3390/s23031583)
- [37] Commission proposes a common European data space for cultural heritage. Online [Accessed 28 August 2024] <https://digital-strategy.ec.europa.eu/en/news/commission-proposes-common-european-data-space-cultural-heritage>
- [38] DiCultHer. Online [Accessed 28 August 2024] <https://www.diculther.it/rivista/cultural-heritage-il-competence-center-e-limpatto-del-digitale-i-progetti-4ch-e-indices-measuring-the-impact-of-digital-culture/>