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TABLE OF CONTENT

From Landscape to Fragment.
Survey, Analysis, Digital Dissemination for The Cultural Industry.

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ABSTRACT: The focus of this article is methodological and is based on a reflection that has at its core the notion of scale. The research carried out, in fact, concerns objects of different dimensions: large portions of non-urbanized territory, historical centers, squares and urban spaces, blocks, single buildings, monumental fountains, sculptures, museum works, archaeological fragments. Obviously, for each context investigated we had to adapt the flow of actions that goes from preliminary knowledge to the formalization of the digital communication product. What are the methodological and procedural variants? And what are the elements that remain unchanged both in the knowledge phase (documentation, survey, graphic analysis) and in the communication phase (modeling, rendering, cataloging and archiving, presentation, educational entertainment)? The examples presented offer the starting point for a reflection on the tools and the procedures currently available to those who deal with knowledge, protection and communication of artistic heritage. Artificial intelligence, the diffusion of digital archives and access to open data further expand an already complex scenario, allowing an ever-greater interaction between those who process the information and those who are intended to use it.

1. INTRODUCTION

This article reports some experiences carried out by researchers at the Laboratory of Survey and Representation of the University of Reggio Calabria, to which the authors of the essay belong. The experiences are related to research projects funded by very different bodies and institutions (EU, Ministry of Cultural Heritage, Local Authorities), but having as a common denominator the survey, graphic analysis and digitization, aimed at cataloging and preserving information.

The focus of this article is methodological and is based on a reflection that has at its core the notion of scale. The experimentation carried out, in fact, concerns six objects of different dimensions: a large portion of non-urbanized territory (*Pietra Cappa*, Aspromonte National Park), a medieval historical center (Gerace, Metropolitan City of Reggio Calabria), some squares and urban spaces (located in the town of Mandanici, Sicily), an Arab-Norman church (*St. Peter and Paul in Agrò*, Sicily), the sixteenth-century *Orion fountain* in Messina, an archaeological find belonging to the *Acrolith of Apollo Aleo* (440-430 BC).

Obviously, for each context investigated we had to adapt the flow of actions that goes from preliminary knowledge to the formalization of the digital communication product. What are the methodological and procedural variants? And what are the elements that remain unchanged both in the knowledge phase (documentation, survey, graphic analysis) and in the communication phase (modeling, rendering, cataloging and archiving, presentation, educational entertainment)? We will try to answer these questions through the following graphs and reflections.

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2. TERRITORIAL AND LANDSCAPE SETTING

The area involved is the *Vallata delle Grandi Pietre*, a geosite of significant historical and landscape interest located in the northeastern part of the Aspromonte National Park. The site is characterized by the presence of rocky emergences shaped by weathering. They show themselves as landmarks that attract perceptual attention and characterize the area. The landscape expresses relevant emotional capacities and presents itself as an ideal place for the practice of cultural trekking: a form of slow tourism that allows the enjoyment of a rugged and forgotten territory. The predominant geological element in the valley is the monolith of *Pietra Cappa*, after which the entire area is named. It is considered the largest monolith in Europe, but in reality, geologically speaking, it is a huge polygenic conglomerate. *Pietra Cappa* covers about 4 hectares and a height of about 140 meters. The lowest part of the monolith is at an elevation of about 700 meters and the summit at 829 meters.

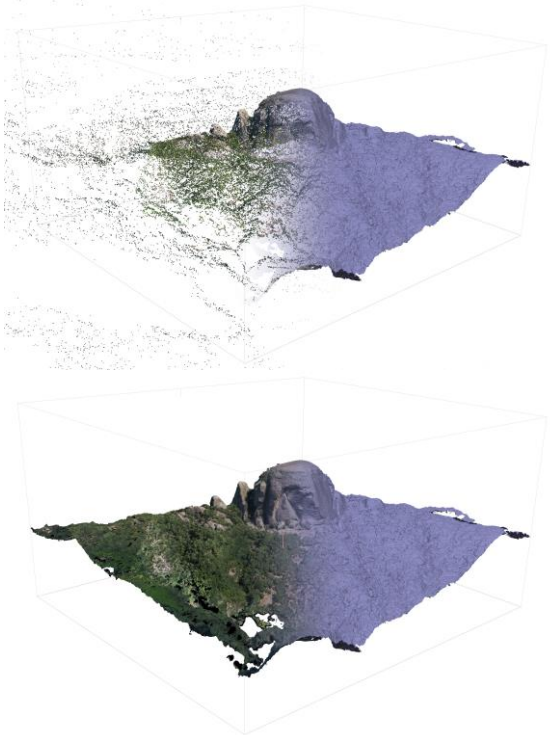

Figure 1: *Two phases of data processing from the photogrammetric survey of Pietra Cappa.*

Pietra Cappa is not the only emergence in the valley. In fact, it is possible to identify other geological signs that characterize the area. Among them, a little more than 1,500 meters southward as the crow flies, is the striking *Pietra Lunga*, which vertically marks a point of perceptual attraction and an opportunity to practice short climbs. To the northeast of *Pietra Cappa*, about 850 meters as the crow flies, is instead the Miocene conglomeratic complex of the *Rocche di San Pietro*, which among its sculptural promontories hides rock cavities that housed small hermit communities of Byzantine rite. Historian Domenico Minuto hypothesizes that the asceterio was frequented in a very remote age, presumably around the 7th or 8th century [1].

In addition to its obvious naturalistic and geological relevance, the *Pietra Cappa* area also has relevant anthropic features that are now in a state of ruins. The remains of the ancient Byzantine fortification of *Pietra Castello* stand out on a promontory chiseled with spectacular inlets that are proposed as spontaneous naturalistic viewpoints. Finally, of significant importance are the ruins of the *Church of San Giorgio* (730 m a.s.l.). They are nestled in a forest of centuries-old chestnut trees, about 500 meters west of *Pietra Cappa* as the crow flies. The ruins are what remains of an ancient Byzantine church, built according to the quincunx typology, a planimetric scheme widely used in Greece and the periphery of the Empire in the middle and late Byzantine period. In 1953 archaeologist Gennaro Pesce carried out an excavation campaign and hypothesized a 10th-century date [2]. Architectural historian Arnaldo Venditti also proposed a similar dating [3]. More recently, studies by Domenico Minuto and Sebastiano Venoso have proposed a date between the 7th and 8th centuries [4].

The landscape and architectural elements were surveyed with image-based and range-based techniques, using laser scans and aerial shots from Unmanned Aircraft System (UAS). The remote surveys were carried out with phase difference laser scanner Faro Focus X 330, using spherical targets with a diameter of Φ 140 mm for the alignment of the point cloud. The two survey data were subsequently integrated and processed for two different purposes: graphic and morphological analysis for professionals and production of digital models for interactive use.

In particular, for the second purpose, the 3D models obtained were optimized in order to minimize the number of graphic primitives. Models related to architectural emergencies were reduced to 50,000 faces, those related to landscape character to about 100,000 faces. This resulted in 3D models suitable for web and mobile app use. In addition, a hiking route was

recorded in GPX (GPS Exchange Format) format that can be used on simple GPS navigators or mobile trekking apps.

Finally, we designed the logical scheme of a mobile app that would be able to exploit all the digital materials acquired in order to create a cultural trekking route for a slow and reflective mode of enjoyment of the landscape and the architectural and cultural emergencies present.

3. URBAN AREA

We have carried out a study focused on the multi-scalar investigation process applied to the medieval historical center of *Gerace* (about 13.5 hectares). The work is part of a larger research project (GENESIS - Seismic Risk Management for the Touristic Enhancement of the Historical Centers of Southern Italy). The main objective of the project is to offer support for the safe and conscious visit of cultural heritage in seismic areas, starting from the knowledge of their history and their morphological and construction characteristics, of the architectural and artistic emergencies, of the potential on which to leverage - also through innovative forms of management, based on the use of new media - to insert them into wider tourist circuits.

Figure 2: *Aerial photogrammetric plan of the surveyed urban fabric, point cloud, Gerace.*

The first operation carried out consists in the aerial photogrammetric survey of the compact historical nucleus, aimed at drafting documentation and analysis graphs. The survey allowed us to obtain a 2D/3D, multi-scale, multi-precision model, navigable with different visualization modes (point cloud, mesh, solid model and textured model). It also allows for the detailed analysis of numerous aspects: metric data (volume-area-length), elevations and differences in level, georeferencing, orthogonal views, horizontal and vertical sections.

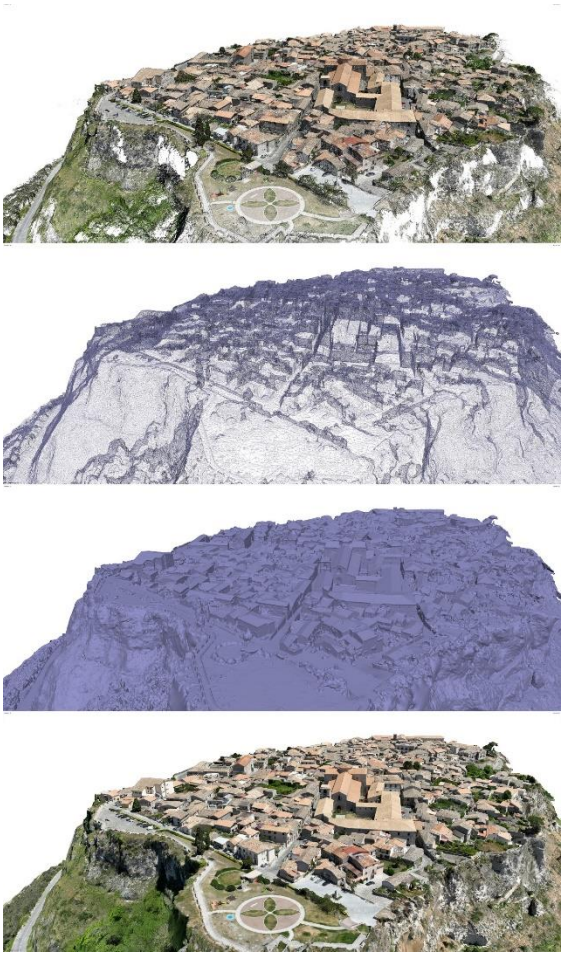

Figure 3: *From top to bottom: point cloud, TIN mesh, solid mesh, textured mesh.*

The model obtained from the photogrammetric survey was integrated with data from the instrumental terrestrial survey. The model obtained through the integration of these two techniques was optimized for insertion into a GIS platform, with the aim of obtaining metric, morphological, qualitative and quantitative information (geospatial, topographic, orthophoto cartographic, from sensors, etc.). Integrating point cloud data with GIS enables better planning across various applications and provides a combination of spatial analysis, visualization, and decision support, enabling more informed and efficient workflows. The point cloud derived from the model can be further integrated into a BIM environment for the execution of Heritage-BIM procedures, or integrated and explored in AR/VR environments, or used as a basis to produce videos and other communication materials [5].
The studies carried out in different fields (both in terms of representation scales and thematic insights) have been merged into an IT platform capable of systematizing the collected data, simulating damage scenarios useful for managing emergency situations, promoting new

ways of enjoying them based on the renewal of the offer and the valorization of new historical-artistic destinations.

The work carried out on the historic center of *Gerace* shows some of the potential offered by the tools currently used for the survey and representation of the historical heritage. Artificial intelligence, the spread of digital archives and access to open data allow an ever-greater interaction between those who process the information and those who are intended to use it.

4. PUBLIC SPACE

The urban public space is delimited by the vertical walls of architecture, buildings, churches and winds through the city. It is a hollow space, an 'empty' in terms of architecture but a 'full' with regard to the enjoyment of urban centers. In small centers, such as *Mandanici* (eastern Sicily), the square gathers a large part of social life, it is the constant setting of the life of the inhabitants. The documentation of the material and immaterial component of these places is, in our opinion, one of the new frontiers that representation aimed at the cultural industry must deal with.

The small village of *Mandanici*, founded around the 9th century by the Arabs, has in its surroundings the monastery of *S. Maria Annunziata*, founded by monks of the Eastern rite. The presence of the monastery testifies to the importance of the center during the 10th and 11th centuries. *Mandanici*, in fact, is located along one of the historic paths that connect the Ionian coast of eastern Sicily with the Tyrrhenian coast. The Byzantine routes, in this territory, wind along the rivers that draw protected and flat paths on the slopes of the Peloritani.

The town is located at the confluence of three rivers: the *Dinarini*, to the west; the *Miceli* torrent, which divides it into two parts; the *Cavallo* torrent, which borders it to the north. The ancient and articulated *via Fabrizi* follows the orographic trend and insinuates itself into the building fabric to flow into the small square of the main church. Here the urban space seems crystallized: protected from vehicular traffic because it is difficult to reach, it is at the center of numerous streets that define divergent directions.

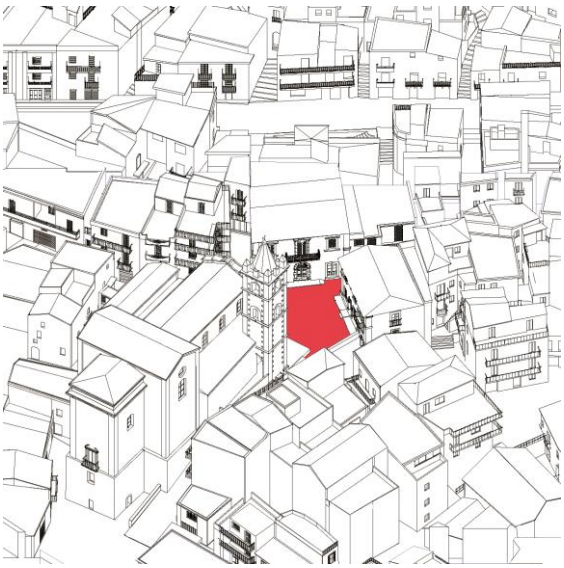

Figure 4: *Santa Domenica square.*

The square is an irregular pentagon that develops on different levels. The architectural backdrops that define it are the facade of the church of *S. Domenica*, and the *Mastroeni-Longo* palace, built between the 16th and 17th centuries with finishes and materials homogeneous to those of the church. Closing the backdrops of the small square is the *Scuderi* palace, contemporary with the *Mastroeni-Longo* one and decorated with the same architectural language.

Figure 5: *Survey of Santa Domenica square.*

The square was surveyed in 2012 with the Faro Focus CAM 2 laser scanner. 15 scans were performed around the perimeter of the external walls of the church. The church was surveyed with seven internal scans. The instrumental survey allowed the restitution of the internal facades of the square. The small size and height of the buildings, in fact, do not allow for optimal viewing. The use of the instrumental survey also

allowed us to verify the correspondences between the stylistic elements present on the facade of the mother church and those of the neighboring buildings.

The survey would have been more effective by integrating aerial shots from an Unmanned Aircraft System (UAS) but in 2012 the photo modeling techniques with drones were still in an experimental phase.

5. ARCHITECTURE

The Arab-Norman architecture that dot the coast of the north-eastern tip of Sicily is a widespread and little-known heritage. A documentation and enhancement project involves the creation of a virtual network capable of narrating the phenomenon and promoting the digital dissemination of architecture that represents the most authentic roots of this territorial area. Here we illustrate the documentation of the church of SS. Pietro e Paolo di Agrò, built in 1117 by Byzantine and Arab workers in the Norman era.

The church, today, appears as the perfect syncretism between three different cultures. The plan is a cross between the central-plan church, typical of the Eastern church, and the three-nave church characteristic of the Latin rite. The wall decorations, obtained with the *cloisonné* technique, are clearly of Byzantine origin. The domes and the connection between the drum and the span are clearly of Maghreb inspiration. In fact, the small domes placed as a signal on the central span and on the bema are extradosed of small dimensions and made without resorting to centering. The church is therefore the ideal field of investigation to verify some hypotheses on the collaboration in the Sicilian territory of three different cultures and craftsmen.

The instrumental survey of the church of *Saints Peter and Paul* allows us to obtain a digital twin of the building. The purpose of instrumental analyses is multiple. On the one hand, we aim to document a state of affairs, to crystallize a situation in the process of modifying the state of conservation of a building. On the other hand, the analyses allow us to travel back in time. They allow us to hypothesize, by identifying the geometry and measurement of the building in each of its parts, the methods of tracing the morphological and structural parts and, therefore, to retrace the construction phases.

The buildings constructed in this period by the craftsmen present in Arab Sicily in the 11th century, just conquered by the Normans, present numerous imperfections in the tracing. Often the basic figures that give rise to the building's layout are visibly asymmetrical or present significant alterations from the ideal geometry. The instrumental survey, combined with the knowledge of the practical geometry manuals of the time and the construction customs, allows for further in-depth analysis.

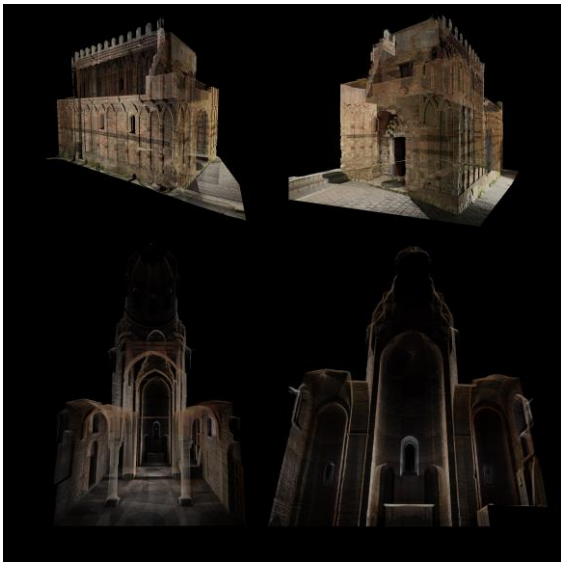

Figure 6: *Survey of SS. Pietro and Paolo*.

The survey of the church was carried out in May 2018 with a Faro Focus 3D laser scanner. 17 external and 18 internal scans were performed. The uncertainty of the instrument is equal to UcRanging = 0.496 mm. The scan alignment process involved the creation of two groups: external and internal, the average stresses in the external scan alignments are equal to 1.9922 mm; the average stresses in the internal alignments are equal to 2.2704 mm. The alignment between the two groups generates average stresses equal to 6.3607 mm. We can therefore say that the average precision of the survey is equal to ± 6.361 mm. It should be noted that the accuracy of a survey is not to be attributed solely to the instrument used but also to the conditions of the building to be surveyed. The church in question is no longer plastered, the internal walls are made of bricks while the external ones have a considerable quantity of different materials. It can therefore be assumed that an uncertainty of ±10 mm, certainly greater than that related to the instrument used.

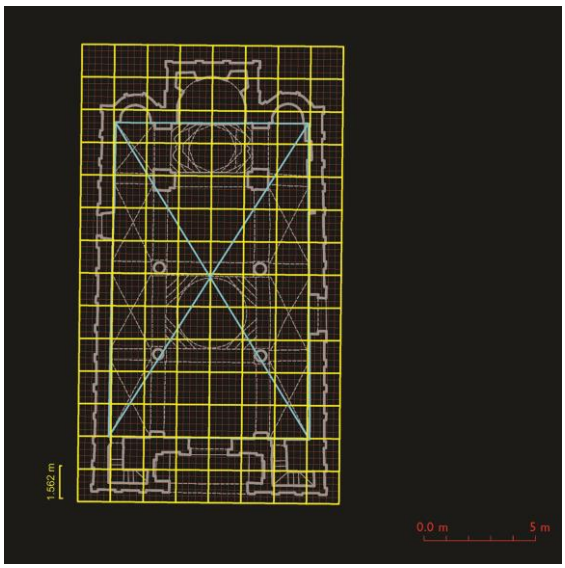

***Figure 7**: Regulatory layout. Byzantine foot, cm 31.25.*

Through the survey it was possible to identify, using the unit of measurement of the time - the Byzantine Foot - the regulatory path underlying the geometry of the plan. Through the digital twin, managed in a CAD environment, it was possible to carry out horizontal sections at the level of the floor level: as shown in the image 7, the hypotheses on the tracing appear fully verified.

6. ARTWORK - SCULPTURE

The methodology of surveying and communicating artistic heritage can be exemplified in a work carried out on the sixteenth-century *Orion fountain* in Messina, by Michelangelo's pupil Giovannangelo Montorsoli. *Orion Fountain*, defined by Bernard Berenson as "the most beautiful fountain of the sixteenth century in Europe", was designed in 1553 to celebrate the construction of the first Messina aqueduct. Montorsoli did not simply designed the fountain: his work extended to the redesign of the entire square. In fact, the fountain had to be considered as a parameter to measure the hierarchy of the built-up space, leading to interpretation [6].

The fountain is not in the centre of the square, but in a secluded position: nevertheless, it represents a microcosm linked to the universality of the water element, personified by the Nile, Tiber and Ebro rivers and by the *Camaro* stream. The *Orion fountain* is also a visual goal for the square; from any position, it stands in the foreground against the background of the surrounding palaces [7].

***Figure 8:** View of the fountain in the Piazza Duomo area.*

***Figure 9:** Survey data processing phases. From point cloud to textured mesh.*

***Figure 10:** Orion Fountain. Two-dimensional and three-dimensional views of the digital model.*

The method used for survey was terrestrial and aerial photogrammetry survey. The survey of the fountain was scheduled assuming a scale of 1:20 graphic rendering, with insights up to the

1: 1 scale. The survey of the urban space was performed through the employment of a laser scanner (in some cases to be integrated with a photogrammetric method). The survey of the urban space was scheduled assuming a scale of 1:200 graphic rendering, with insights up to the 1:100 scale. The survey phase was followed by the execution of the 2d and 3d representation (horizontal and vertical sections, elevations), scale 1:50, 1:20, 1:10, 1:5; similarly, the representation in 2d (plan, profiles) and in 3d of the urban space (1: 200, 1: 100).

The survey problem was solved in a fairly simple way using an image-based technique; more complex was the analysis of the relationship between the monument and the context which, due to repeated disastrous events, has changed several times over time, modifying the perception of the monument.

7. ARCHAEOLOGICAL FINDS

The digitized finds, housed at the *Museo Archeologico Nazionale* di Reggio Calabria (MArRC), belong to the *Acrolith of Apollo Aleo* (440-430 BC). They were found in 1923 during the reclamation of the *Punta Alice* marsh near Cirò Marina. The finds were among the remains of a temple that archaeologist Paolo Orsi, following excavations between 1924 and 1929, identified as the *Temple of Krimisa*, dedicated to *Apollo Aleo*.

Originally, the statue had a height of just over two meters. It is one of the rare examples of acrolithic technique in Magna Graecia. The acrolith was a sculpture of which only the extremities were carved in marble: the head, hands, and feet. The body, instead, was made of a wooden structure, covered with cloth drapes. The findings of the *Acrolith of Apollo Aleo*, available to date, are: a head, 41 centimeters high, whose eye sockets are hollowed out; the two feet, with holes in which the wooden support structure was inserted; and a fragment of the left hand.

There are some traces on the remains that suggest the presence of elements that are missing today. On the head was a wig probably made of gold foil or gilded stucco, as inferred from the holes into which it was grafted. The eyes were made of bone and glass paste, while the eyelashes were made of bronze foil. Finally, there are small holes on the feet through which sandals were attached.

In 2016, the National Archaeological Museum of Reggio Calabria decided to make an installation with a hypothesis of the original configuration of the acrolith [8]. At the time of Paolo Orsi, immediately after the discovery, a copy of the head had already been made, which is still in the possession of the Museum today. For the realization of the installation it was necessary to make prototypes of the two feet and the hand fragment, with high reliability of the morphological and chromatic characteristics. Therefore, the Museum asked the *Mediterranea* University of Reggio Calabria to make digital copies and prototypes of these artifacts.

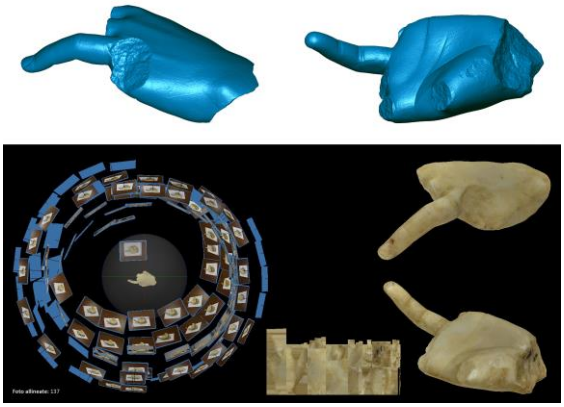

Figure 11: *Acrolith of Apollo Aleo. Processing phases of the survey, digital model and reproduction by 3D printing.*

On this purpose, a two-stage digital survey was carried out: the high-precision survey (with 0.02 mm resolution) carried out one with Faro CAM2 ScanArm monochrome scanner-laser was later supplemented with a SfM (Structure from Motion) survey. In fact, the scanner-laser used provides very high accuracy but allows obtaining 3D (high poly) models without color. Therefore, a second digital surveying process with SfM was carried out. The datasets derived from an accurate photographic survey were subsequently processed using digital photogrammetry software (Metashape). Thus, we obtained a second set of digital (low-poly) models with lower accuracy but with data on the color characteristics of the surfaces. Then, we extracted the texture and UV mapping of the (low-poly) models and, after appropriate color corrections, applied them to the scanned (high-poly) models. The resulting textured 3D meshes were optimized by reducing them to about 1 million faces, the optimal size for prototyping with the 3DSystem ZPrinter® 650 printer.

The prototypes were used by the museum to set up an installation that reproduces a hypothesis of what the *Acrolith of Apollo Aleo* must have originally looked like. Thus, while preserving the integrity of the original artifacts, it was possible to create a dissemination system with educational purposes that brings museum visitors closer to the origins of the artifacts and prompts them to learn more about the acrolithic techniques of classical antiquity.

8. CONCLUSION

The six examples presented offer the opportunity to reflect on the tools and procedures currently available to those who deal with surveying for the knowledge, protection and communication of artistic heritage. We have compared surveys of objects of different sizes, with consequent restitutions at equally different scales; the physical-geometric characteristics are also varied, as they range from large natural elements (Pietra Cappa) to geometrically defined architectures, up to stone elements characterised by accurate details. The tools used are the same, the techniques are identical (terrestrial and aerial photogrammetry, laser scanner). The substantial difference consists in the design approach towards the survey and the subsequent processing.

The digitalization of cultural heritage is a crucial activity to promote accessibility to historical, artistic and documentary heritage, thanks also to the opportunities offered by new technologies. It is a powerful tool, capable of preserving the historical-artistic heritage, making it accessible and enhancing it while safeguarding our identity.

Today it is easy to make leaps in spatial and dimensional scale and verify increasingly sophisticated vision and representation systems: thanks to augmented, mixed, immersive reality, we can appreciate the material consistency of things through the immaterial of the virtual, identifying with works of art, making them accessible thanks to open, inclusive and democratic modes of fruition.

Artificial intelligence, the spread of digital archives and access to open data further expand an already complex scenario, allowing for ever greater interaction between those who process information and those who use it.

9. ACKNOWLEDGMENT

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The drone surveys of *Pietra Cappa* were carried out between September and October 2023 by forester Dr. Francesco Manti with UAS/drone Dji Mavic 2 Pro, with the collaboration of Dr. Elvira Castiglione; the remote surveys were carried out by Domenico Mediati and Paolo Sergi.

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The survey and graphic renderings of the *Orion fountain* were made by Miriam Ferrara and Ilaria Fiumara.

The surveys and elaborations of the *Acrolith of Apollo Aleo* were carried out by Francesca Fatta, Domenico Mediati and Andrea Marraffa.

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