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DIGITAL GYPSOTHEQUE. ONLINE FEATURES AS INCLUSIVE EDUCATIONAL TOOL

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Abstract

The paper deals with the first results of an ongoing research on the issues of digitization of CH for educational and museum purposes. The research starts from the study of the small plaster casts collection kept inside the Santa Croce complex at the University of Cagliari. The workflow aims to investigate the potential of advanced technologies by reconciling the needs strictly related to the two principles of measurement and visualization. The construction of an information system will facilitate not only the classification and management of the digital plaster collection but also communication for scientific and didatic purposes. Two different possible applications are considered: the first for the construction of a web platform for the remote interactive query of the database, the second for the virtual visit of the rooms that host some of the casts through the delivery platform for point & click games developed in the PAC-PAC research project.

Keywords

Digital cultural heritage, online collections, virtual environments tour, structure from motion, plaster cast collections.

1. *The plaster cast collection of the Cagliari School of Architecture*

During the eighteenth and nineteenth centuries plaster cast collections had great diffusion, providing their role as a medium with the original work of art until the early twentieth century. Following the renewed interest in the classical world, in the eighteenth-century plaster casts spread to academies and art schools as a teaching aid or as a tool for drawing and modeling exercises. Private collectors, european courts or artistic circles also created their own cast-plaster collections.

During the nineteenth century, Italian universities set up collections of plaster casts, primarily used as a teaching aid for archeology. Plaster casts played a fundamental role in distant countries such as America, to transmit the artistic and cultural values of Western civilization to people who otherwise would not have been able to appreciate those works of art (McNutt, 1990).

The cast collections offered a variety of architectural, artistic and decorative elements in a convenient, economic and immediate way. Universities, schools and academies offered plaster casts collections with scientific and didactic function. Plaster casts played an important role in the training of painters, sculptors and architects, finding their main foundation in the exercise of drawing. Casts are not just simple teaching tools, over time they take on further meanings spreading in private collections or in museums with galleries entirely dedicated to shortage copies of original artifacts that could thus virtually cross the borders of the countries of origin (Born, 2002).

Having overcome the idea of casts as objects only suited to the function of didactic and scientific tool for students and researchers, today there is an increasing need to make the collections accessible to a non-specialist public (Flashar, 2013). The value of a historical document and educational usefulness for a non-academic audience give these collections unprecedented meanings and roles. Towards these new values it is necessary to orient museographic and communication criteria in order to make this heritage more understandable and attractive to various categories of users.

As evidenced by an inventory register, the School of Architecture of the University of Cagliari bought fifty-seven casts between the years 1904 and 1911. The register, kept at the Library of the Faculty of Engineering and Architecture, for each cast acquired reports the inventory number, the description, the date of purchase, the amount of the cost and the date of unloading of a total of fifty-seven plasters.

Fig. 1: A plaster cast currently kept at the Department of Environmental Civil Engineering and Architecture (DICAAR) in Cagliari

Fig. 2: One of the labels that certify the paternity of the casts to the Carlo Campi company in Mila**n**

Of these fifty-seven casts originally present in the School of Architecture, twenty-three are still found today (Fig.1). Thanks to the labels on the back of four casts (Fig.2), it is possible to easily go back to the firm of Carlo Campi in Milan, which at the beginning of the twentieth century certainly represented the most authoritative and prestigious laboratory in Milan for the execution of plaster casts (Nicoliello, 2017). In fact, Carlo Campi's workshop operated in Milan for institutions such as the Accademia di Belle Arti and the Consulta del Museo Patrio di Archeologia, receiving various commissions from Sir Thomas Armstrong, director of the Department of Science and Art of the South Kensington Museum in London. Carlo Campi also collaborates in integrative restorations with the Ufficio Regionale per la Conservazione dei Monumenti di Lombardia (Nicoliello, 2017).

While for some casts it was not possible to identify exactly the original sculptural element, for others examples of casts of the same element were found in some online collections. this is, for example, the case of the cast depicting the head of Medusa, for which a similar copy can be found in the Royal Academy collection in London.

Fig. 3: The plaster cast of a Parthenon frieze (west frieze, slab II, figures W 2, W 3) kept at the University of Cagliari, Department of Civil Engineering, Environmental Engineering and Architecture. The original frieze is part of the collection of the British Museum, London.

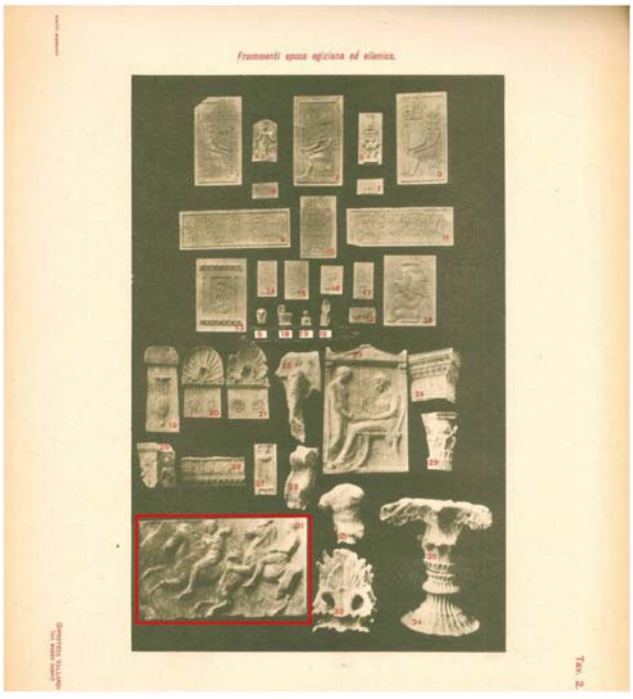

Fig. 4: A page from the illustrated catalog of the Vallardi Gipsoteca showing the plaster cast of the Parthenon Frieze (framed in red) corresponding to the one kept at the DICAAR.

Fig. 5: Digital cast after plaster cast

According to the Royal Academy website, the plaster would refer to the cast of patera (libation bowl) with Medusa head from the frieze on the north side of the Temple of the Divine Vespasian in Rome (Figs. 14, 22, 35). The presence of several casts of our collection in the sample and illustrated catalog of the Vallardi Gipsoteca (Figs. 3,4), where in 1927 the models of the Campi Museum merged, leads us to hypothesize that probably all the casts were purchased by the same company in Milan.

The collection of casts is currently kept in various rooms of the Department of Environmental Civil Engineering and Architecture (DICAAR) within the Santa Croce complex in Cagliari. The lack of adequate space does not currently allow for an exhibition that enhances the collection, currently available only for occasional use by staff and students. Following an initial census of the casts still present within the School, in order to reorganize them and to make the collection accessible to a wider audience, a workflow was tested for the construction of a web platform for consultation and 3D visualization. The project is part of a broader research aimed at reorganizing and communicating the didactic tools of the past in the School of Drawing of the University of Cagliari.

2. *Digital transitions: digital casts after plaster casts to visually experience ancient art*

One of the first issues that arise when we represent the reality around us concerns the degree of similarity between the perceived phenomena and its representation. Replicas have always been viewed with disdain, but thanks to the plaster casts people were able to visually experience ancient art in every part of the world (Born, 2002).

Today the plaster casts document the culture that has pervaded Western societies in the recent past centuries, placing these artifacts as witnesses of nineteenth century cultural aspirations.

The digital model, like the plaster cast after antique sculpture, aims to define a "cast" of the original artifact (Fig.5). This apparent contrast becomes even more acute when we deal with digital acquisition and modeling techniques. The perfect coincidence of the observed reality with its representation is always and, in any case, a pure illusion: every graphic representation is not only a body of knowledge, but also a way of knowing and thinking.

Dealing with objects that have the main purpose of replicating other objects, certainly this question emerges even more forcefully when we want to provide the replica of what, in itself, is a copy of something else.

Actually, this dichotomy is overcome when we recognize the absolute autonomous value of plaster casts both in an artistic, historical and cultural sense: cast is much more than just a copy of the original artifact. Although the objection of the adherence between reality and representation still persists and deserves to be always further investigated, especially when fidelity in reproduction becomes one of the main features of digital acquisition tools and techniques, the advantages offered by digital technologies for different purposes are numerous and considerable.

In past centuries plaster cast could take on different meanings depending on the contexts of use, ranging from mere reproduction with an aesthetic function to objects of study and teaching tools in schools of art and architecture. Certainly, the main and perhaps most interesting function was the intermediary role that these artifacts established between the 'original works' and scholars in areas where a direct study of the original artifacts was not possible.

The "digital cast" of these artifacts is not a mere virtual reproduction of an art object: digitization is aimed at contexts with very different purposes from those for which the plaster casts themselves were born, first of all that of the potential offered by online exhibitions and virtual museum dedicated to heritage communication and cognitive improvement (Daniela, 2020; Pescarin, 2014; Valzano & Mannino, 2020), reducing the distance between visitor and cultural heritage and also increasing interest and promoting a visit to the site in person (Leong & Chennupati, 2008).

Today, the plaster casts have no rate as a simple replica that refers to the meanings of the original, as it did in the past, but mostly for its own absolute value as artistic expression, testimony of a culture and an art that are now almost forgotten. In this sense, the replica made from plaster casts takes on an autonomous value detached from that of the original object, loading and enriching itself with very different meanings and values compared to those of the original one in the historical and artistic context.

Considering the "degree of similarity" in reproducing the original artefact, one of the first evident differences between digital and plaster casts lies precisely in the different "fidelity" of the digital copy compared to the plaster one; this is even more evident when we start from the manipulation of discrete models gathering from image-based and range-based survey technologies.

Compared to the complex technique of plaster casts, fully placed in the context of the practices matured in the history of the statuary technique, digital acquisition and modeling techniques certainly do not aspire to reach the same degree of detail that we can find in the plaster casts, which are able to very faithfully replicate the original artifacts; in digitization the construction of the model is mainly addressed to extracting information related to the characteristics in the third dimension of casts, and often cultural or even morphological and material qualities are difficult to translate.

The digital model often loses those artistic values deriving for example from the practices and techniques adopted in the creation of the original work, qualities that instead easily remain in the plaster cast. The main purpose of the digital 3D model is therefore not to replicate the hidden meanings present in the original object, it would be a wrong goal from the start, but rather to allow remote accessibility of the objects, even at the expense of a perception that only the original work will still be able to transmit. The sense of representation is not to equal the value of the original artefacts nor to transmit all the values that we recognize in them: as in every "translation" process, as is the one implemented by drawing and digital modeling, every attempt to fully reproduce all the qualities inherent in a work of art as well as in a common object would be in vain.

Without denying the value of measurement precision which constitutes a fundamental issue in the processes of architectural knowledge, today we must recognize further possibilities offered by successful 3D modeling completed primarily for

visualization by way of image-based survey procedures. The research aims to reconcile the needs strictly related to the two principles of measurement and visualization within 3D models. The low-cost approach of Structure-from-Motion (SfM) photogrammetry was adopted for the survey of the casts, a methodology that proved to be quite flexible and very effective for the research objectives. The construction of an information system will facilitate not only the classification and management of the digital plaster collection but also communication for educational and museum purposes.

Through the delivery platform for point & click games developed in the PAC-PAC (Point-And-Click per il Patrimonio Ambientale e Culturale) project[1], the research also provided for a virtual visit of the rooms that currently host some of the casts. In addition to the advantages offered by 3D digitization for the documentation and study of the casts, the workflow aims to experiment possible applications of remote fruition of this collection, assuming a further value and meaning connected to the online accessibility of cultural heritage.

3. Online collections

We live today in an increasingly technological and connected society, defined in the fundamental essay for understanding contemporary culture by Henry Jenkins as 'convergent culture'. With this definition, Jenkins refers to a context in which every kind of content is digitised and published on sites, platforms, social networks, and local networks, involving all kinds of communication forms, from advertising to fiction, from public administration services to corporate communication, from consumer fiction to scientific texts (Intorre, 2013).

It is within this panorama that the promotional and educational activities carried out by cultural operators, art historians, academics, librarians, and museum directors take place; they find on the web the possibility of conveying to the outside world the information related to the corpus of works in which a multiplicity of different users are interested in various ways, thus reaching a potentially infinite public. These communication systems have proved to be very useful for the dissemination of cultural heritage within the particular historical moment we are living in with the pandemic, in which it would have been difficult (or sometimes impossible) to physically participate in exhibitions, installations and so on. The possibilities offered by technology, such as digital communication elements like augmented reality, ICT (Information and Communications Technology) and virtual reality allow the user to live an engaging and sometimes immersive experience, further stimulating the willingness to learn of the average museum user. With the Covid-19 pandemic crisis, the enhancement of remote use for cultural heritage has seen the recovery of old projects and the birth of new ones on the web platform, also through the use of robotics with innovative applications that provide for the presence of the robot on site and the visitor connected remotely (Cigola et al., 2014).

An innovative example was the temporary exhibition "Gallery One" by the Cleveland Museum of Art, Cleveland (USA), which, through game experiences, intrigued and encouraged visitors to linger on the works, offering them also the possibility to create personalised paths. The museum, therefore, is also a digital medium, offering culture through the web, using different languages, adapted to the field of reference, thanks to which it can attract a wider audience and convey its message in an innovative way (Canova, 2015). An example of this is offered by The Metropolitan Museum of Art, which has created a separate section on its official website dedicated to children called #metkids. Every aspect is taken care of so that children can explore independently and learn while having fun. (Fig. 6,7).
We can say that the museum constitutes the link between the work of art, the exhibition space, and the user. It is a space that displays objects, creates narratives and experiences, which through the process of setting up are proposed to the user, thus acquiring meaning and value. (Fig. 8).

For the new museum, which today has a communicative and not only informative function as a messenger of memory (Glusberg & Baragli, 1983), it is important that the message reaches the user.

[1] Coordinated by prof. Ivan Blečić and created by the University of Cagliari - Department of Environmental Civil Engineering and Architecture (DICAAR), PAC-PAC is a research and technology transfer project funded by Sardegna Ricerche, which aims to promote the environmental and cultural heritage of Sardinia through interactive video games and fiction.

Fig. 6: Interactive map intended for children MET | Metropolitan Museum of Art, New York

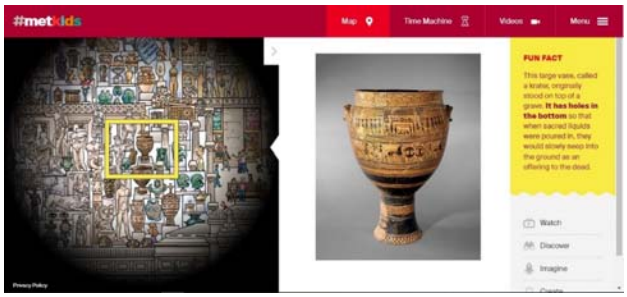

Fig. 7: Layout interactive map for children MET

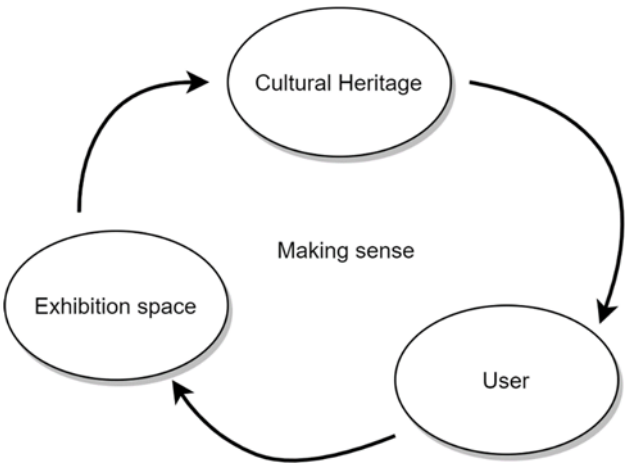

Fig. 8: The opera acquire sense by the relation between cultural heritage, exhibition space and user

This is possible for example thanks to digital storytelling, i.e. a narration realised with digital tools in order to obtain a story made up of multiple elements of various formats (video, audio, images, text, maps, etc.) to involve the public at a deeper level with the aim of guaranteeing an immersive experience consisting of identification and empathy. The works in the museum's collection are defined as Cultural Heritage (CH), those immovable and movable goods of artistic, historical, archaeological, ethno-anthropological, archival and bibliographical interest and evidence of the value of civilisation.

Contemporary museums collect and pass on knowledge through intangible material assets of memory, which are often accompanied by digital heritage obtained through the digitisation or reconstruction techniques mentioned above. Digital Heritage (DH) is therefore the digital cultural heritage, sanctioned by UNESCO as an inalienable component of Cultural Heritage (CH), the heritage of mankind. Through information technology, cultural heritage becomes the object of new forms of dissemination, thus changing traditional cultural-historical production and consumption activities and identifying new paths of signification, using the huge amount of digital data.

From a communication point of view, a process of digitisation of the resources concerned, whatever their nature, is used to manage a database made available through the web. The preservation and organisation of digital cultural heritage is done through archives, consisting of the repository, which is an unstructured collection of digital material, and metadata, which is data about the material in the repository.

The digital archive represents a technological and conceptual innovation for different types of exhibition spaces, which has improved and renewed the way culture is transmitted. The digital repository brings together all the digital cultural assets of a museum and can host various forms of objects including collections of texts, images, videos and 3D models representing the museum's works, 360° panoramic photos of exhibition spaces, animations, renderings and videos explaining events related to the works, textual information and descriptions, audio files, electronic brochures and maps.

One of the world's largest digital archives is held at the Smithsonian Institution. It is the largest museum, education and research complex in the world, with 19 museums and the Natural Zoo. The Institution was founded in 1846 thanks to funds donated by the English patron James Smithson (1765-1892), who expressed the desire to create an institution for the increase and dissemination of knowledge, and that it be named after him.

The Smithsonian Institution continues to honour this mission, making it relevant to the demands of today's public. To this end, a separate Smithsonian 3D digitization section has been created, where a small group of technologists work

to focus their research on developing solutions to further the Smithsonian's mission of "increasing and disseminating knowledge" through the use of 3D scanning technology, analysis tools, and our delivery platform. (Fig. 9)

This work is already transforming the core functions of the Institute's affiliated museums. Researchers in the field can now return not only with samples, but also 3D data documenting entire sites. Curators and educators use 3D data as a basis for telling stories and sending students on a quest for discovery. Conservators use 3D data to track the condition of a collection item over time using 3D deviation analysis tools, showing exactly what changes have occurred on an object [https://3d.si.edu/about].

A second relevant example, especially as a point of reference for the development of a proposed digital archive in the next step of our research work, is the British Museum. As for other museums already mentioned, it has a specific section, British Museum Images, where a team of the museum takes care of creating and making available high-quality images of the collection in its possession, as an aid in scientific research. In addition to photography, they are also working on 3D models of some of the works in the collection, which are being implemented using architectural photogrammetry [https://www.bmimages.com/].

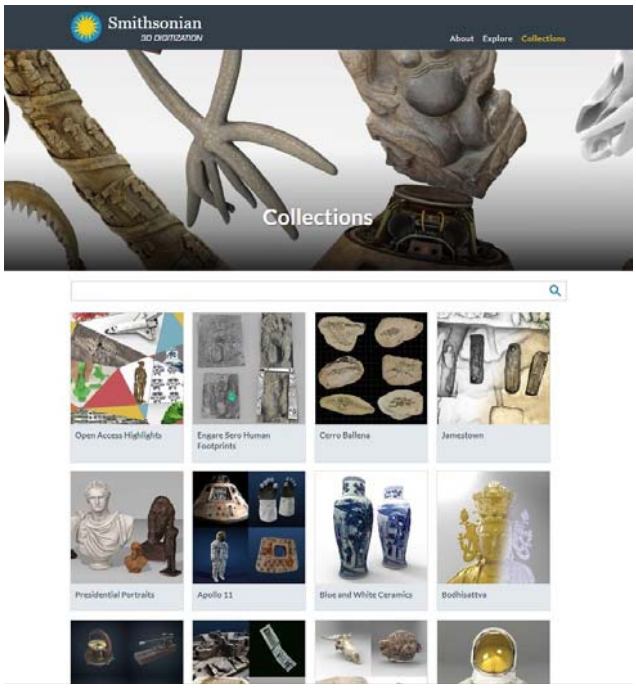

Fig. 9: Digital Archives of the Smithsonian Institution foundation. (3d.si.edu/collections)

For this purpose, the institutional website of the museum relies on an external platform Sketchfab, specially created for the uploading and visualisation of the 3D models, which can be queried remotely.

4. Virtual accessibility to heritage artifacts

The accessibility of historical artefacts is often severely restricted, both physically and immaterially. While on the one hand this can occur to ensure the protection of artefacts, not infrequently the cause is the lack of spaces in which artefacts can be made accessible, as well as the lack of past opportunities for study and information gathering. The particular health condition of the pandemic currently affecting the entire planet is certainly emblematic; the necessary limits to visibility imposed by health safety are a perfect example of how even normally accessible artefacts can suddenly become inaccessible to most people.

Whatever the issues that lead to this sort of "isolation" of objects, digitisation provides countless possibilities for opening up information to users (Lo Turco et al., 2019). Where the nature of the artefact allows it to be surveyed, in the broadest sense of the term, it is possible to make available in a rapid and structured way a whole series of useful, if not indispensable, information for studying the artefact. This information can range from dimensions and geometries to chemical-physical, historical, and archival characteristics, and can be processed and enriched at any time, without having to come into contact with the physical object.

Fundamental for an efficient exchange of information is its structuring; only through a study of the organisation of data, thanks to a standardised and shared classification, is it possible to allow users with different skills to benefit from the same data (Schweibenz, 2019). When we talk about structured data in the digital field, one of the first tools that comes to mind are relational databases, real tables of information connected through relationships between data.

Given the nature of the research and the aims set, the implementation of a database for storing and sharing the data of the gallery was the most logical choice. With the creation and "compilation" of such a database as the objective, the workflow was organised accordingly (Fig. 10).

4.1 The database structure

Designing the database one of the first steps was to identify, initially and briefly, what archival information could be found in the library's documentation. This allowed us to hypothesize the first items that could be linked to each artefact, even when some of this information was currently missing. At this stage we therefore planned to indicate for the various plaster casts the author and/or the workshop that made the cast and the year of its purchase or creation; since for some casts in the inventory the reference to the original work was also indicated, it was decided to implement this data as well. A research supported by data on the author has also allowed us to ascertain that some of the objects appear in some catalogues, information that has been implemented.

Once an initial census of the artefacts had been completed, we proceeded to identify their location within the spaces of the Faculty, to give a general description and to survey a first series of measurements; all this data constitutes further entries in our database. With regard to the headings author/workshop, location and cataloguing, it was decided to create further tables to provide more information such as the author's personal details, biography if present, and city of work; if the pieces are present in catalogues, the title, year, publisher and a brief description will be noted. Lastly, as far as cataloguing is concerned, it was decided to draw up a list of positions, coded according to a hierarchy of rooms, so that the owner, building, floor, and room can be identified.

The decision to include such a broad classification of rooms is dictated by the desire to make the database expandable and modifiable later, even if the various artefacts are moved. All the geometric-dimensional information obtained from the photogrammetric survey will be added to the first structure of the database (Fig. 11).

In order to simplify the input of information, a compilation mask was created at the same time as the database structure was designed. This constitutes the interface with which future operators will interact with the database and will guide them through the various phases of implementation of the information, at the same time giving indications on the standards established for the formatting of the data.

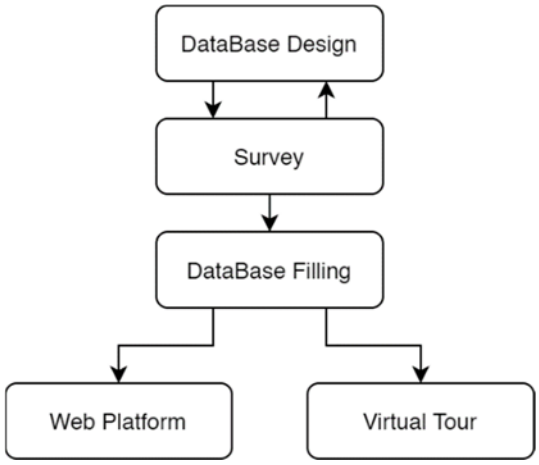

Fig. 10: Schematic diagram illustrating the workflow of the research.

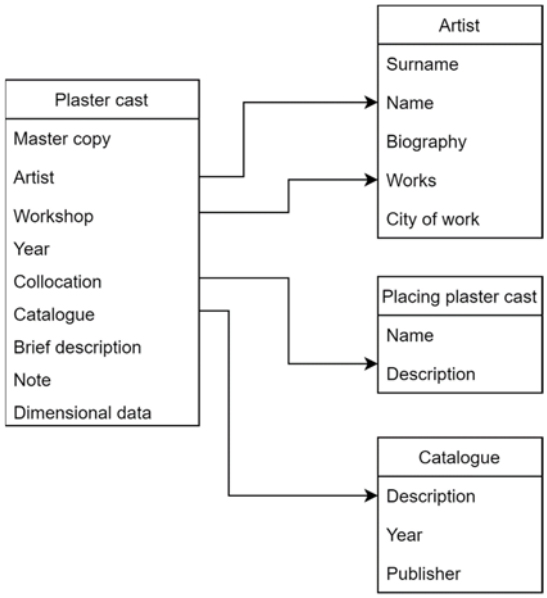

Fig. 11: Chart of the database structure

The internal consultation of the data contained in the database will also take place in a similar way, for example through the local network of the univesity; to this purpose, a second interface was envisaged, in this case for read-only use, in this way users will be able to carry out queries to find an artefact, a specific author or workshop, or even a list of all the artefacts conserved in a specific location. The consultation interface has currently been designed for the exclusive use of specialised users, such as teachers, technicians, or students; this has led to a very concise and functional formulation of the mask, precisely because of the "research" use that is envisaged in this phase of the research. This obviously does not preclude the possibility of implementing later a second mode of

consultation, oriented to users outside the academic world, and therefore with greater attention to aesthetics and with a lighter organisation, suitable for a more didactic or popular consultation.

4.2 Survey and 3d modelling

On the basis of what we have seen with some of the case studies, with this work we proceeded to detect 13 of the 23 works surveyed, through the photogrammetric survey in order to obtain remotely searchable 3D models, to be included in the previously described database, and from which to extrapolate 2D and 3D graphic elaborations, assuming their sharing on an online platform or a specially created web page, for the networking of the collection of plaster casts of the School of Architecture of the University of Cagliari.

Photogrammetry is a detection method that allows you to define the position, shape and size of objects on the plane, using the information contained in suitable photographic images of the same objects, taken from different points. It is a low-cost method, fast and with a methodological approach applicable to all types of casts. Initially it was tested on some plaster casts with very different characteristics, the collection in fact consists of bas-reliefs, high-reliefs, and all-round reproductions, and we set the working methodology by setting the number of photos, the light, the angles and the number of markers needed in general, implementing them as needed.

The image-based technique, aimed at an accurate and reliable 3D reconstruction, required data processing with the Agisoft Metashape Professional program, and a refinement of the work with CloudCompare and Adobe Photoshop. The first phase, setting of the set (Fig.12), is the preparatory one for capturing the frames, taking care to verify the complete coverage of each artifact. For a better result and since in some cases the works were particularly complex in shape or texture, we placed markers around the find, automatically generated by the circular 12bit type software, to facilitate the subsequent alignment phase. For the movable works (small objects such as capitals, modillions, antefixes and friezes) a support surface has been prepared with a uniform background that is not too light, so as not to compromise the detachment from the white of the work and make the processing phase easier (Fig. 13). While for the works affixed to the wall, such as the patera of Medusa and the frieze the Cavalcade of the Parthenon, the markers were placed directly on the wall around the object in varying numbers depending on the size and complexity of the artifact (Fig. 14). Once the preparation of the "set" is completed, we proceed with the capture of the frames. We used, for the realization of the photos, a Sony A5100 mirrorless camera with 24MPix resolution and the possibility to save photos in RAW format. The camera equipped with a 16-50 lens was set to a focal length of 30 - 35mm, depending on the individual cases. To obtain the maximum possible depth of field, so that the object is perfectly in focus, we have chosen to reduce the aperture, at the expense of exposure times [aperture priority setting]. With the camera set up in this way, we proceeded to create the set of photos for each exhibit, obtaining from a minimum of 20 photos to a maximum of 96 photos for more complex objects and an average of 45 photos for medium-complex works.

The photos were taken by keeping the object fixed in position and rotating the camera around the work by 360°, for mobile works and 180° for those hung to the wall. This operation was completed by making a minimum of 3 and a maximum of 5 complete turns with different angles (top, front, bottom), to cover the entire work and minimize blind spots.

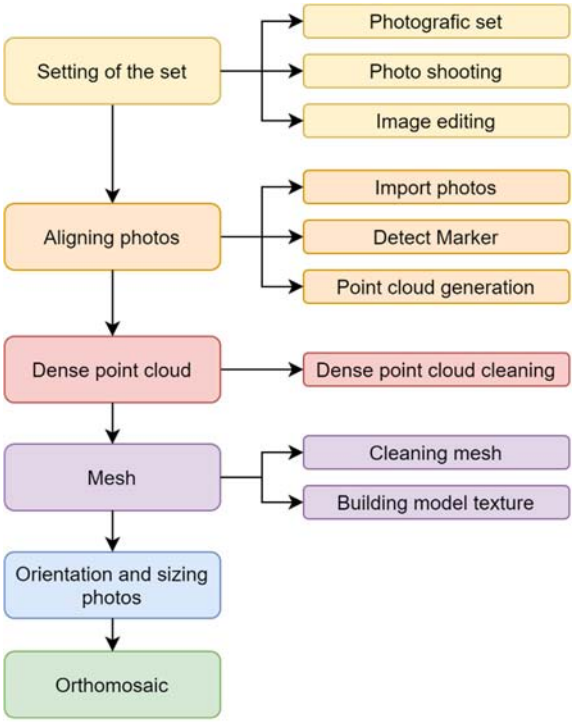

Fig. 12: Workflow photogrammetric survey

Fig. 13: Example of small cast. (area of cornice with egg-and-dart).

Fig. 14: Example of cast hanging on the wall (patera with Medusa head from frieze)

The collected images were first converted from RAW to tiff format, to which the exposure was improved to have a better result in the processing phase, and were thus uploaded to the Metashape program (Fig. 15).

Aligning photos | The following step is to detect the markers proceeding with the alignment phase.

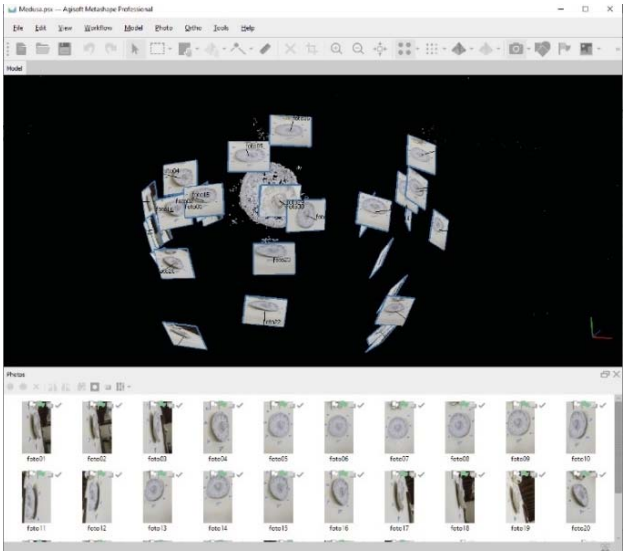

Fig. 15: Cast of patera with Medusa head: frame processing for the creation of tie points

The program searches for homologous points on the images and combines them together. The resulting image alignment results are displayed in the form of a scattered point cloud (tie points) (Fig. 16). For some works it was necessary to go back to the alignment phase, adjust the positioning of the markers manually, sometimes, add some new points before restarting the allignment process.

Orientation and sizing photos | For greater convenience we have preferred to proceed already during the alignment phase to the orientation and sizing of the photos, by identifying three points with known distances between them, in our case identified thanks to a triangular ruler (Fig. 17), and to a first elimination of points of external parts to the object (furnishings and other extraneous elements present in the scene).

Dense point cloud | We then move on to the creation of the dense cloud of points (dense cloud), starting from the scattered cloud (tie points). The dense cloud of points can be built by the software based on the estimated camera positions and images themselves (dense stereo matching). Generated photogrammetric point cloud can be merged with LIDAR data or automatically divided into several semantic classes following the project tasks. The creation of the dense cloud of points took at least 1h and 30 min up to a maximum of 2h, depending on the number of photos. Also, in this phase it was preferred to further clean up the cloud from all points external to the work in question, before continuing with the creation of the mesh surface, and subsequently of the texture (Fig. 17).

Mesh | The fourth phase consists in the generation of a 3D surface (mesh) and/or 2.5D (DEM) starting from the dense cloud. Polygonal model (mesh) can be textured for the photorealistic digital representation of the object / scene and exported in numerous formats compatible with the post-processing software, both for CAD and 3D-modeling workflows (Figs. 19, 20).

Orthomosaic | In the last phase it is possible to proceed with the creation of an orthomosaic, which can be georeferenced, and from which it is possible to extrapolate measurable sections used to model the find (Figs. 21, 22). The workflow set up in this way made it possible to complete the set goal of digitization, modeling and restitution of more than half of the works in the collection.

Except for some precautions (insertion of a higher number of markers during the alignment phase, variable focal distance depending on the work and the difficulty of the scene, insertion of masks on the frames on the restitution software to eliminate the objects that it was not possible to exclude at the when the photos were taken) the working methodology can be applied to the rest of the works, not yet digitized and in general extended to mobile finds, whether in the archaeological or architectural field. The information (textual and graphic) thus obtained was collected in an initial filing, created for each of the 13 casts surveyed, which will flow into the online database (Fig. 23).

4.3 Online consultation portal

One of the tools that allows extremely wide accessibility to the information of databases similar to ours is undoubtedly that of online consultation portals (Leong & Chennupati, 2008). The creation of an information access portal, a direct transposition of the consultation mechanics already described when discussing data reading masks, hypothetically allows anyone with web access to query the database.

Since in these first steps of the work the creation of a public interface available online constitutes only one of the possible ways of using the database, we decided to simply hypothesise its possible schematic structure. This structure gives an idea of what technologies and means may be necessary if we decide to proceed with the realisation of the online portal.

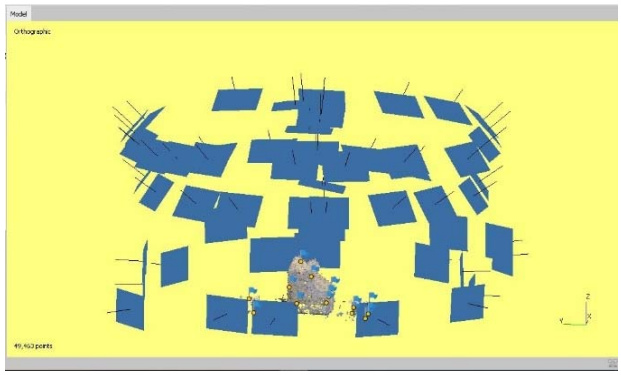

Fig. 16: Cast of modillion- "Aligning photos"

Fig. 17: Cast of modillion - "Building dense point cloud"

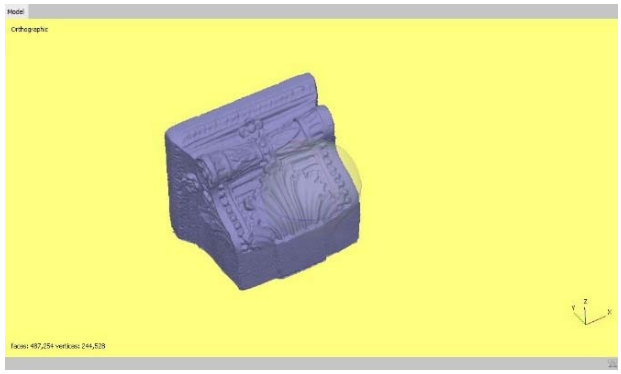

Fig. 18: Cast of modillion – "Building solid mesh"

Fig. 19: Cast of modillion - Building model texture

Fig. 20: Cast of modillion - Orthomosaic

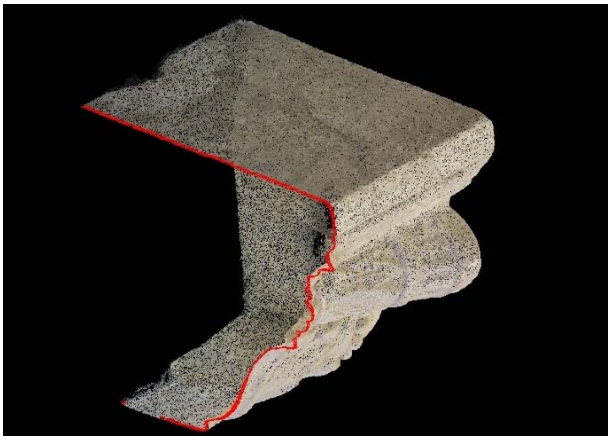

Fig. 21: Cast of modillion - Cross section obtained starting from the dense point cloud

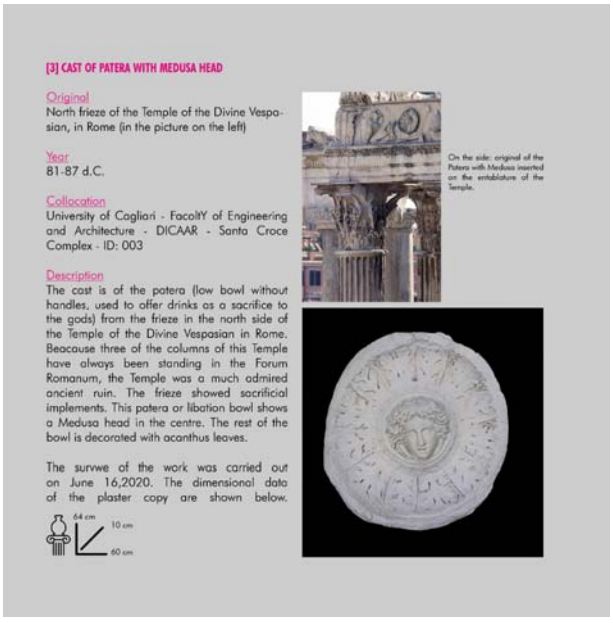

Fig. 22: Cast of patera (libation bowl) with Medusa head

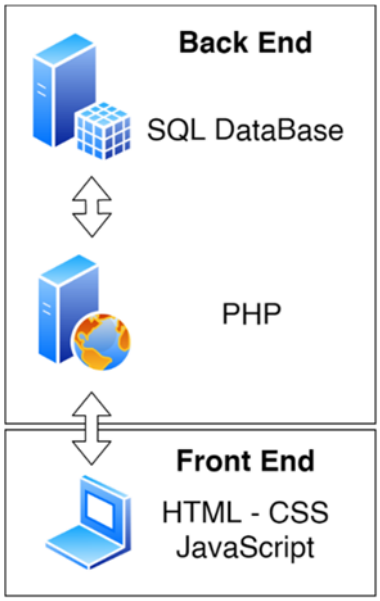

Fig. 23: Scheme of a classic access system to a SQL database

The chosen structure is one of the most basic, but widely used: the SQL database is queried on the server side by means of PHP pages, to which the user interfaces on the client side by means of classic HTML - CSS pages with JavaScript and AJAX scripts (Fig. 23).

The possibilities of configuring web pages for consultation are numerous, and their actual design, as already mentioned, is beyond the scope of this research.

It was therefore decided to create simulations using mock-ups, taking as a reference the digital model consultation portal used by the Smithsonian Institution and the British Museum, as they are very similar to the idea of a possible application designed for the online consultation of our models (Figs. 9, 24). In particular, the British Museum provides users with a tool to visualise three-dimensional models, thanks to the use of the Sketchfab platform (Fig. 25).In a manner not too different from that used by many video streaming platforms, Sketchfab allows the creation of real catalogues whose contents the user can filter and view in various ways.

Considering the digital models obtained from the survey to be an extremely effective communication tool, a possible insertion of visualisation tools following the same logic was evaluated.

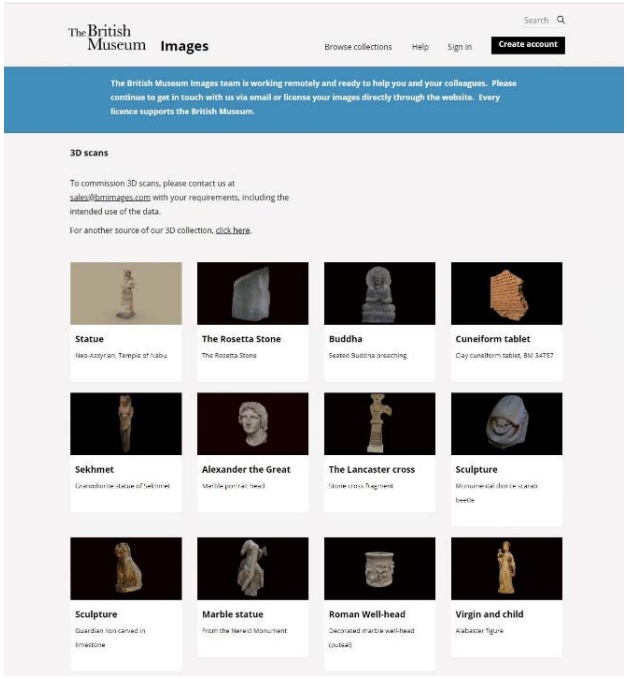

Fig. 24: Digital archive of the British Museum images section

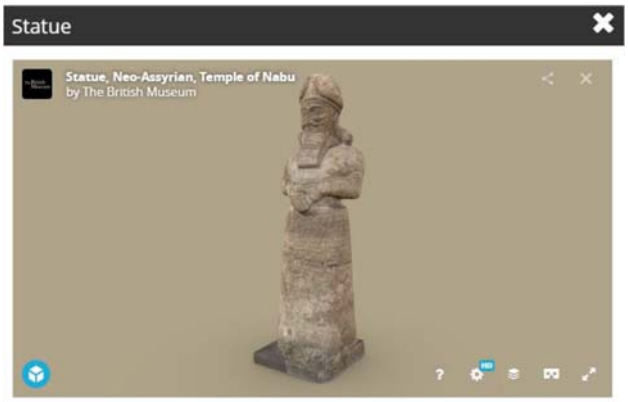

Fig. 25: An example of 3D model visualization in the Sketchfab platform

However, given the limited number of artifacts analysed at the moment and the purely simulative nature of the portal, the choice of platform for uploading the model online fell on the P3D.in service, a free portal entirely analogous to Sketchfab. P3D.in allows the loading of three-dimensional objects in OBJ and FBX formats with relative textures; the models can then be manipulated by means of rotation, pan, and zoom tools, in different display modes, for example excluding textures or applying a wireframe view (Figs. 26, 27). A sample of a consultation portal page (Fig. 28) has been set from a mock-up based on the British Museum page adapted to our case study.

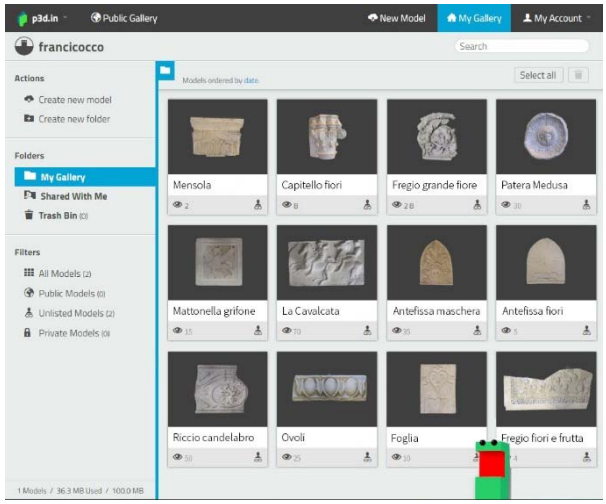

Fig. 26: Catalogue of 3D models in P3D.in

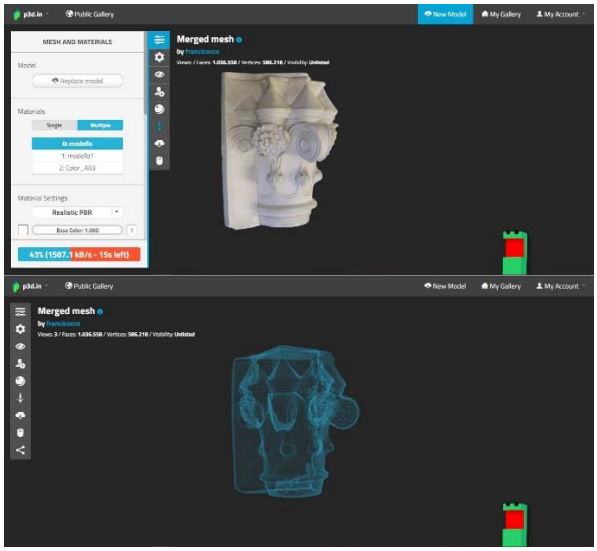

Fig. 27: Different visualization options of 3D models in P3D.in, textured (top) and in wireframe mode (bottom)

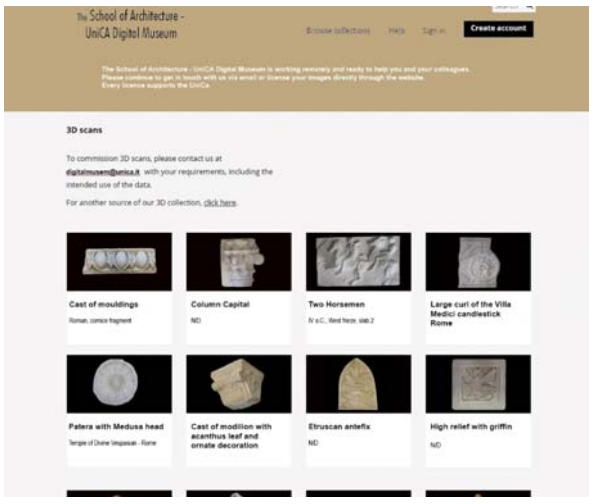

Fig. 28: Mockup of the online consultation portal

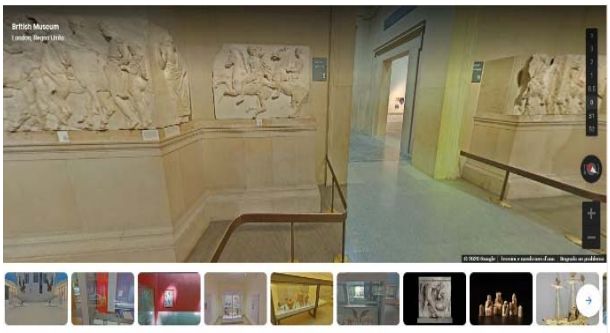

Fig. 29: Virtual Tour of The British Museum

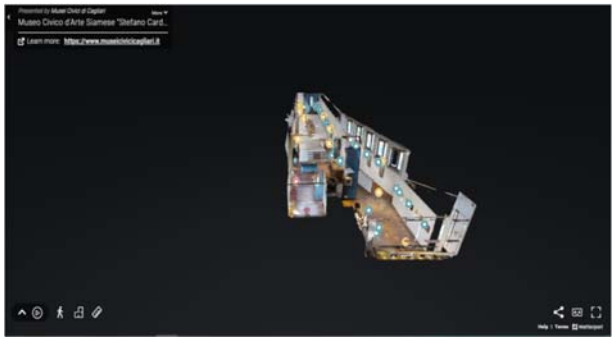

Fig. 30: Virtual Tour of "Museo di Arte Siamese" in Cagliari

Fig. 31: Virtual Tour of "Musei Civici di Cagliari"

4.4 Virtual spaces tour based on PAC-PAC platform

Access to information through online consultation portals is certainly one of the most intuitive and user-friendly methods that can be used, but certainly not the only one. Another alternative, among the possible ones, is the use of tools to provide greater user involvement, such as virtual tours.

The British Museum itself offers an example of virtual fruition, not only of the artefacts but also of the spaces destined to host them, through a virtual tour of some spaces (Fig. 29); very similar fruition modalities are also offered by the Museum of Siamese Art (Fig. 30) or by the Civic Museums of Cagliari (Fig. 31).

In this first phase of the research, however, it was considered interesting to think about an approach slightly different from the simple virtual tour, intended as mere navigation within digitally reproduced physical spaces. Simultaneously with the beginning of this research, in the Faculty of Engineering and Architecture of Cagliari, a proprietary authoring platform for point-and-click adventures is developed within the PAC-PAC project (Fanni et al., 2019).

The PAC-PAC project aims to provide an intuitive and easy-to-use tool for users who have no previous knowledge of coding but are willing to try their hand at developing a point-and-click game, with the specific aim of promoting and enhancing the heritage in its multiple aspects (Fig. 32). As the project progressed, the development of the working method was accompanied by the design of several prototypes that demonstrated how the PAC-PAC software can also offer valid ideas outside the specific category of point-and-click games to which it refers (Piano & Cuccu, 2020).

In our workflow, it was decided to experiment with integrating the information contained in the digital plaster cast database with the PAC-PAC platform, in order to explore the possibilities offered by an immersive environment such as the one under consideration.

The space virtualisation system at the basis of PAC-PAC is in fact made up of video or photos, not only classic but also in panoramic format (so-called 360° media); this therefore allows the user to be immersed in a space that is a highly faithful representation of reality, with media that are immediately produced and easy to transmit or manage. This does not however exclude the use of alternative methods of representation or hybridisation between photorealistic systems and others of greater abstraction. Specifically, the PAC-PAC software was used to recreate a series of environments in which part of the collection's plaster casts are kept. As mentioned, these environments can be explored at 360°, thus providing a spatial context for the artefacts, and are also able to transmit some of the sensory perceptions offered by physical environments, such as lighting conditions or ambient noise (Figs. 33, 34).

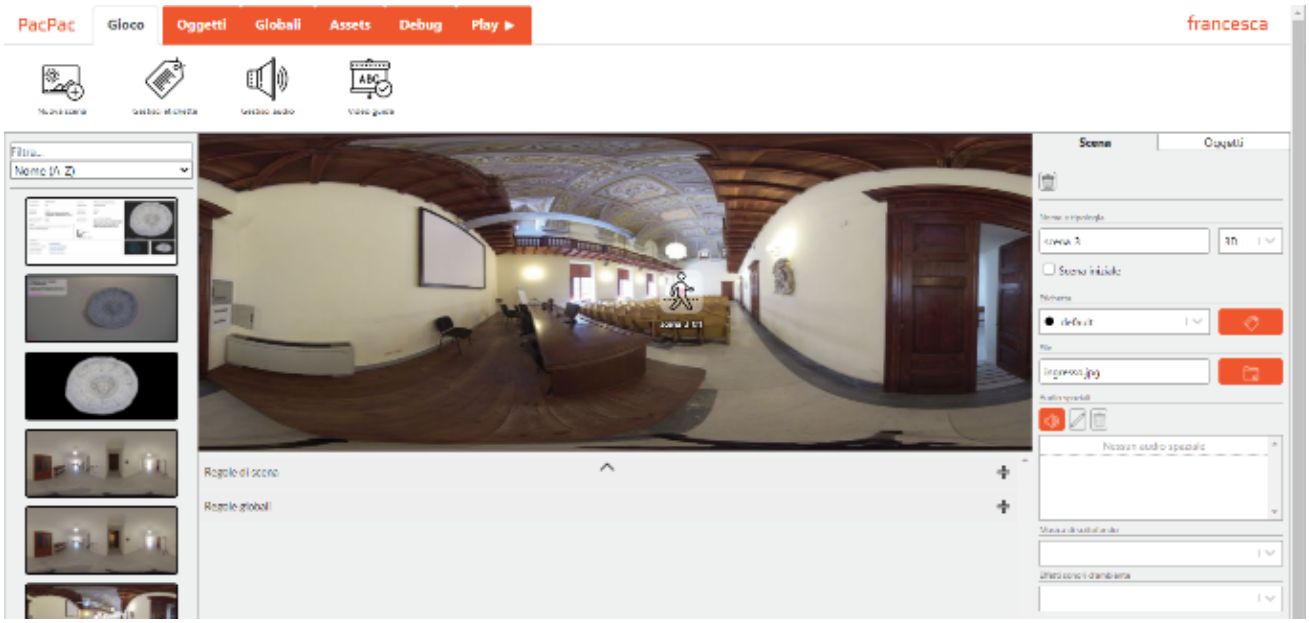

Fig. 32: PACPAC platform interface

Fig. 33: One of the scenes of the tour. In the centre, a movement mark is visible

Fig. 34: A scene of the tour showing three manufacts, enlightened to make them easier to identify

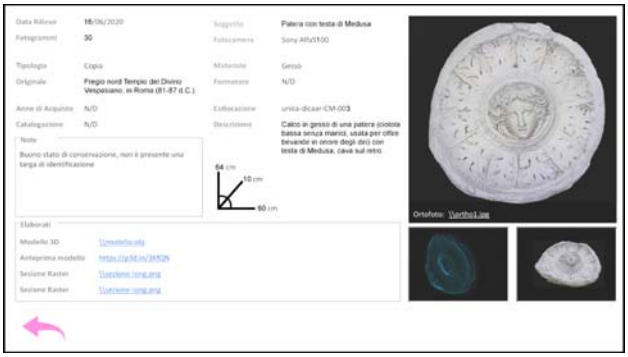

Fig. 35: Clicking on the image of an artefact opens a window with the related analytical-descriptive sheet

Links, called transitions in the software, have been inserted into the environments, allowing new "scenes" to be opened, in which the user can view images of the individual artefacts, see models from various angles or consult the thematic sheets already presented (Fig. 35).

The result of this initial experimentation is a tour that is extremely quick and easy to develop, which is also easy for users to use, thanks to the intuitive mechanics of point-and-click games. In the approach analysed on the use of PAC-PAC, two further aspects deserve attention: the simplicity of expansion of the "network" of environments used, and therefore of the artefacts that can be inserted,

and the "gaming" mechanics that the platform offers.

Regarding the expandability of the tour, thanks to an organisation by independent scenes linked together, it is possible at any time to create new scenes, whether they refer to new environments or new points of view; with the same simplicity it is also possible to create new scenes of artefacts or implement new information in pre-existing ones.
As far as the gaming mechanics are concerned, PAC-PAC was born as a support tool for the development of games, and as such it offers a series of tools, called in-game objects, which open up numerous ways of using and involving the user; some examples may be the gradual discovery of information with a logic of unlocking conditioned by the exploration of the environments, the inclusion of small puzzles or mini-games linked to the information provided to the user-player.

5. Conclusions

The casts embodied and conveyed the ideals of classical civilization, gaining an aid in learning and understanding the history of art. For a long time, the plaster casts have been stored and forgotten in the warehouses of museums and educational institutions and only in recent times has there been a revaluation and rebirth of these collections. Perhaps in some ways they can still continue to retain their role as evidence of original works of art, but the digitization of tangible artifacts further increases our distance from the values and tastes of an era by now gone. Despite this, in many ways digital technology recognizes and affirms that value of the replicas already announced by the plaster casts.

The pandemic crisis has highlighted even more the fragility of a system in which, with the closure of museums and cultural sites, there were very few alternatives to access heritage and information in any capacity. Digital technologies can define new responses and unprecedented models of use by effectively filling many gaps highlighted by the Sars-CoV-2 pandemic (Clini & Quattrini, 2020).

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