Virtual Canova: a Digital Exhibition Across MANN and Hermitage Museums

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Abstract

The paper presents the results of a scientific collaboration between the Interdepartmental Research Center Urban/Eco of the University of Naples Federico II and the MANN (*Museo Archeologico Nazionale di Napoli*, National Archaeological Museum of Naples).
The research activity was aimed to the digitisation, design, and development of an AR/VR-powered narrative experience regarding Antonio Canova's statuary that is currently exhibited at the MANN, loaned by the Hermitage in St. Petersburg: Cupid, Hebe, Dancer, Cupid and Psyche, the Genius of Death and The Three Graces.
The project is motivated by the will to realize an active example of a digital museum, where cultural and formative experiences related to the fruition of architectural and artistic artifacts can be relived over time, even when manufacts are not physically and/or temporally located in the space where the experience takes place.

Keywords
digitisation, photogrammetry, digital museum, Unreal Engine, virtual/augmented reality.

Canova and the Ancient: the exhibition

Antonio Canova's artistic production is strongly tied to the city of Naples.
The so-called "modern Phidias" arrived in Naples in 1780 to admire the beauties of the city and the antiquity of Ercolano and Paestum. He was always greatly fascinated with the classical ruins, and with the majestic art of museums and urban galleries. His travel notes recount his visits to Cappella Sansevero, to the Gallery of Capodimonte and to the museum of Portici. At that time, the latter hosted a collection of the antique manufacts from the ruins in the Vesuvian area. In his recollections, the sculptor associates Naples with Heaven. The "marvellous beauty" that he sees in the city leads him to develop entrenched relationships of study and work in the territory, and their results can still be admired nowadays. Some gypsum moulds, realized by Canova to study and draw the nude during his period at San Carlo delle Mortelle, are kept in the Plaster Cast Gallery at the Naples Academy of Fine Arts.
Following the artist's directions, a portrait statue commissioned to him by the king Ferdinand IV of Bourbon is exhibited in the niche of the Monumental Staircase of the National Archaeological Museum of Naples since 1821.
Plebiscito Square is dominated by the statue of Charles III, crafted by Canova and commissioned by the king's son, Ferdinand I of Bourbon, after he regained the throne of Naples as the King of the Two Sicilies. Actually, the king requested Canova the completion of the equestrian monument that was meant to be dedicated to Napoleon by Joseph Bonaparte, and later by Joachim Murat.
In addition to the mentioned works exhibited in the city, other "Neapolitan" productions by the artist are not located in Naples, for various reasons. One example is represented by the marble statuary 'Venus and Adonis', realized for a temple in the garden of marquis Francesco Maria Berio's palace in Via Toledo and now in Geneva; 'The Vestal', a work realized for the count Paolo Marulli d'Ascoli, left Naples for Switzerland, and then for the Getty Museum in Los Angeles; the sculpture 'Hercules and Lichas', conceived by Canova for the Neapolitan Onorato Gaetani, was then bought by the Roman Giovanni Torlonia and never reached Naples; we know only the chalks of Caroline and Joachim Murat's marble portraits, carved during the French decade, as the statues were lost.
The events here reported clearly highlight the relationship between the master Antonio Canova's art and Naples, or in general, classicism.
These considerations led to the realization of the exhibition '*Canova e l'Antico*' (Canova and the Ancient) at the MANN in Naples, within a vast action programme, characterized by a high scientific value, and at the same time by a keen eye to modernity [Giulierini 2021a; Giulierini 2021b]. The exhibition was curated by Giuseppe Pavanelli, and open from the 28th march to the 30th June 2019; it has been the first one to highlight the continuous, intense and fruitful relationship between Canova and the classical world, exalting his figure as "the last of the Ancients and the first of the Moderns". Hence, only this Museum could allow the development of such a complex and fascinating proposal, which related Canova's creations with the great works from the past.
The exhibition was divided along two floors of the Museum and presented the whole variegated artistic production by Canova, from drawings, sketches, to gypsum and marble, with first-class masterpieces.
The loans from the Plaster Cast Gallery of Possagno, the Museum of Bassano Del Grappa, the Bohdan and Varvara Khanenko National Museum of Arts in Kiev, and the Naples Academy of Fine Arts played a fundamental role.
The exhibition was enriched by the technological support, which allowed providing information on the initial section and on the unit with the tempera paintings from Possagno, restored with the support of the MANN. The final unit contained some shots by the photographer Mimmo Jodice.
The keystone of the exhibition was represented by the sculptures from the Hermitage in St. Petersburg: this museum and the MANN are related by a 4-year protocol, begun by Maurizio Cecconi and supported by Villaggio Globale International. These sculptures include the renowned statuary of the Three Graces, exhibited in the charming Meridiana Salon, together with all the other statues from the Russian museum. (P.G.)

Canova and the Future: the *Virtual Canova* project

Virtual reality (VR) is nowadays an indisputable technological solution to many challenges: making it possible to create environments that simulates the real world and create interactions, it guarantees experiences that would be impossible otherwise, just as in the case of virtual museums exposing operas that are not physically available because of many reasons. Since the 90s, virtual spaces called "virtual museums", where present on the Internet aiming at disseminating art experiences online. The further step from online dissemination toward onsite experience extension was just a question of time and of VR devices cost decrease.
Many definitions of VR can be found in the literature but almost in any of them the following concepts are systematically present: simulation, interaction, and immersion. In a virtual environment users can interact with the operas and with the environment, VR generates a deeply realistic sense of immersion. Many virtual tours have been described in literature [for a review see Loaiza Carvajal et al. 2020] pictorial art is frequently considered as the type of art to be shown, as introduction of 3D digitation techniques as those depicted in this work, are still poorly spread in the related scientific community. The introduction of low-cost VR visors and the use of laser-scanner and photogrammetry opens to a new ecological environment where visitor can enjoy of an interactive virtual space with almost the same amount of degree of freedom of the "real" reality, and sculpture museums become an ideal training ground for new mediality.
The idea of the Canova experience come out by the will of some of the authors of this work to maintain and extend the presence of Canova in Naples. The artist already left important signs of his art in the city, while spreading his masterpieces all over the world, and when the exhibition at MANN was designed, which included loans of artworks that probably we will never see again in Italy, the occasion to scan the operas and maintaining their flavoral presence in our town was really too tempting. (F.C.)

The Digitisation Project: Container and Content

The digitisation was performed on six marble statues by Canova, coming from St. Petersburg and included in the exhibition 'Canova e l'Antico' organized at the MANN in Naples: Cupid, Hebe, Dancer, Cupid and Psyche, the Genius of Death and The Three Graces.
The acquisition of geometric and chromatic data was carried out on the architectural context and on the statues – at a more detailed scale – in order to realize the 3D representation of both the digital collection and its room, in compliance with the dual relationship between the container and the content.
Hence, morphometric and radiometric data from the Meridiana Salon – the room where the Russian collection was exhibited – have been collected first, through a TLS survey campaign, The room was surveyed with 12 planned scans, performed with a phase-modulating laser scanner, Faro Focus3D X330, setting the maximum distance between the range maps acquired to 10 metres. The distribution of the station points was related to the spatial design of the exhibition. In fact, exhibited sculptures and materials were collocated according to a complex geometric design, in order to allow the visitors to move fluidly around the art works. As a consequence, the position of the TLS has been chosen so as to cover the whole space, considering the occlusions caused by the statues because of the incidence angle of the infrared illuminator on their target surface (Fig. 1). The spatial configuration of the environment and its architectural characteristics have led to choose an average scan resolution of 6 mm at a distance of 10 metres. These parameters resulted to be suitable for the digitisation of the Meridiana Salon with a sufficient degree of accuracy and detail, with respect to the goal of the research.
In order to simplify the following phase of range maps alignment, a number of spherical targets were located at several points in the area and framed during the shots. The position of these targets has been designed so as to guarantee their visibility from different locations, in particular from points that presented criticalities with respect to the alignment of scans.
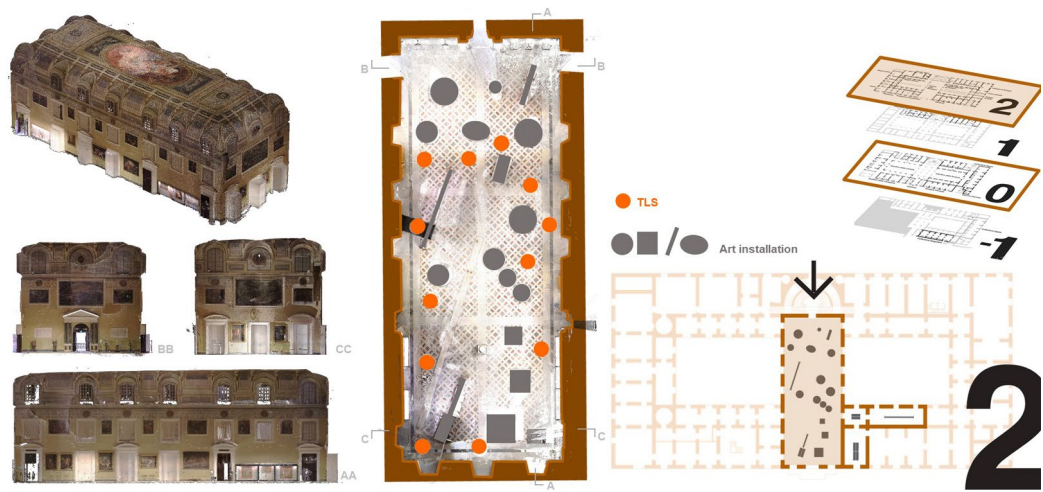
Fig. 1. Meridiana Salon, MANN. TLS Survey.

The 12 range maps have been aligned with the proprietary software FaroSCENE, through automatic geometric primitive fitting algorithms on the considered elements (spheres and planes). The automatic procedure required no additional manual integration of further homologous points for this survey, as no alignment errors occurred. The tension between the targets on each scan is within the range of 1 mm. The registration of the final point cloud, constituted by around 230 million points, was performed in FaroSCENE. It allowed processing several orthophoto mosaics related to the pavement of the Meridiana Salon: as detailed in the following, this was aimed to reconstruct a virtual setting for the fruition of the digitized collection, yet keeping the characteristics of the real venue of the exhibition.

The second data collection was carried out on the six statues by Canova.

The digitisation of the statues has been performed by photogrammetry: successive photographic shots were taken with a Reflex Canon EOS1300D camera, with an on-axis shooting system, by moving around each statue along a circular path. The photos have been taken at different heights: from the bottom, few centimetres above the floor, with an image tilted upwards; at eye level, with the image plane parallel to the dominant plane of each statue; with a telescopic rod, with the image plane tilted downwards. The telescopic rod was used both because of the significant height of the marble sculptures (some almost reached the height of 2 metres), and for the system adopted by the MANN for the exhibition. All the surveyed statues were located on a 30 cm tall platform, round or square-shaped depending on the case. Moreover, while some statues were exhibited alone, others were coupled with statues that did not belong to the Russian collection. So, the shots were made more difficult by the obstruction and the shadows produced by the coupled statues.

During the acquisition stage, a huge focus was given to the lighting conditions, and to their effects on colourimetric data and shades. In fact, big light sources had been placed above the platforms for the exhibition: this condition led to the presence of incoherent shadows on the statues, projected downwards by the light sources in the top. Moreover, the colour temperature – they were warm lights – also affected the realism of colourimetric data, which will be detailed in the next paragraph. The need to overcome this situation led to use a pair of spotlights on a tripod during the photographic shots; the colour temperature of the light was varied as appropriate, and the tripod was moved as the images were acquired, by rotating it around the statues (Fig. 2).

The photographic dataset collected for each statue was processed in compliance with the established practices of digital photogrammetry. The obtained data allowed drafting a synthetic comparative framework that outlines the dimensions of each statue, the specific characteristics of the exhibition design, and the dimensional relationships between the statues and the visitor (Fig. 3). (V.C.)
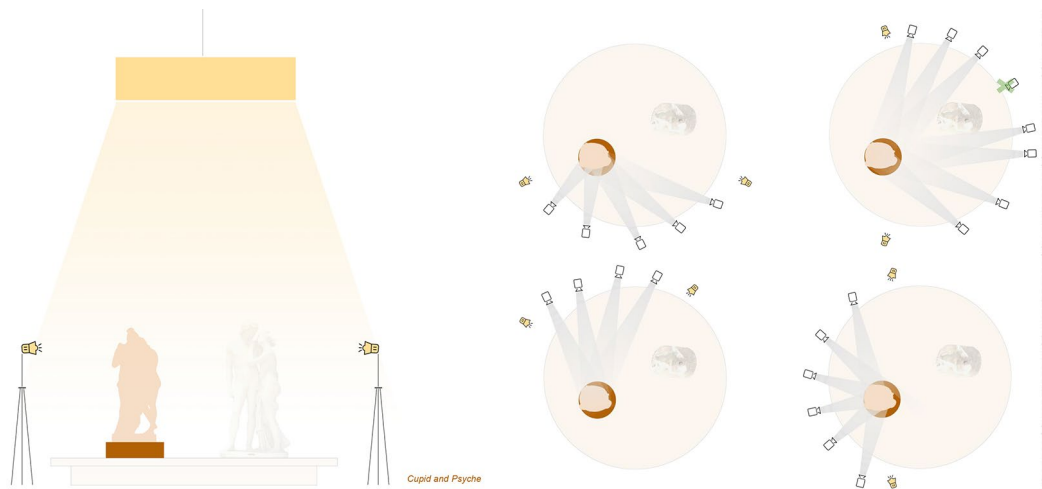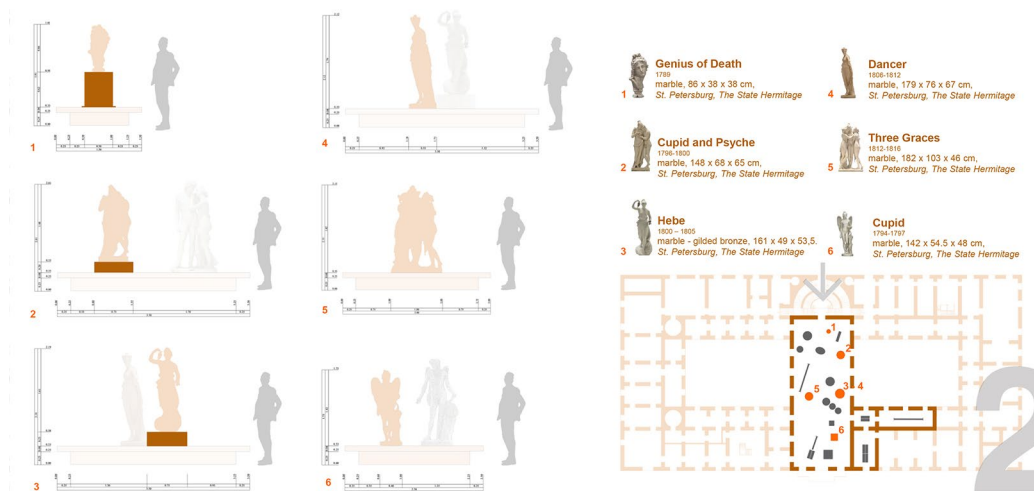
Fig. 2. Image acquisition system with spotlights.

Fig. 3. Synoptic comparative table.

Cupid and Psyche

1	**Genius of Death** 1789 marble, 86 x 38 x 38 cm, *St. Petersburg, The State Hermitage*		4	**Dancer** 1806-1812 marble, 179 x 76 x 67 cm, *St. Petersburg, The State Hermitage*
2	**Cupid and Psyche** 1796-1800 marble, 148 x 68 x 65 cm, *St. Petersburg, The State Hermitage*		5	**Three Graces** 1812-1816 marble, 182 x 103 x 46 cm, *St. Petersburg, The State Hermitage*
3	**Hebe** 1800 – 1805 marble - gilded bronze, 161 x 49 x 53,5. *St. Petersburg, The State Hermitage*		6	**Cupid** 1794-1797 marble, 142 x 54.5 x 48 cm, *St. Petersburg, The State Hermitage*

The Design of the VR Experience

The fruition experience was designed in Unreal Engine, with a strong focus both on the manipulation of the digital models and on the information content associated to them.
In first place, the manipulation processes of the digital models have been studied in order to identify the most opportune modalities of graphical simplification for the elements of the collection. The goal has been to achieve a high degree of fluidity in their use in VR/AR applications, yet keeping a high level of photorealism [Campi et al. 2019; Cera et al. 2018].
Starting from the point cloud, a high poly mesh was obtained using Delaunay triangulation (Fig. 4). Since this type of mesh has a very high density and is not suitable for real-time rendering, decimation strategies were applied. Quadric Edge Collapse [Cignoni et al. 2008] was applied first to reduce the number of polygons, with a minimal impact on visual quality (Fig. 5a). Then, retopologisation allowed reconstructing smaller parts of the statues that were incorrectly recorded during the survey phase [Perticarini et al. 2020]. For example, the latter was performed on the cup held by Hebe in her left hand. This element had not been correctly reconstructed because of the lighting conditions and of its specific material: these led to the presence of strong shadows, which hindered Structure from Motion algorithms. Hence, it was necessary to operate manually, with a nurbs modelling of the cup based on the partial data acquired through photogrammetry (Fig. 5b). Likewise, some details related to the anatomical features and shapes of the human body required an intervention of retopologisation, by placing vertexes and mesh polygons (an example is represented by the posterior calves of the Cupid).

To further reduce the computational power needed to render the statues in real time, a more aggressive decimation step was applied to obtain low poly meshes. This led to the loss of geometric details: normal maps and ambient occlusion maps were then computed to simulate them. These maps were obtained by using a Texture Baking procedure, considering the difference between the high poly mesh and the corresponding low-poly version. For some of the more complex statues, full-scale decimation did not provide good quality meshes, so it was necessary to decompose the initial mesh in sub-parts and apply the procedure to them separately.

To implement the virtual visiting experience, Unreal Engine 4 (UE4) was used. UE4 is an industry-grade photorealistic engine, employed to manage real time interactive 3D experiences. Over the last 30 years, it has been mainly adopted by the gaming industry to produce many AAA titles. More recently, the applications of UE4 have also been extended to other fields, such as Architectural Design, Virtual Production and Simulation.

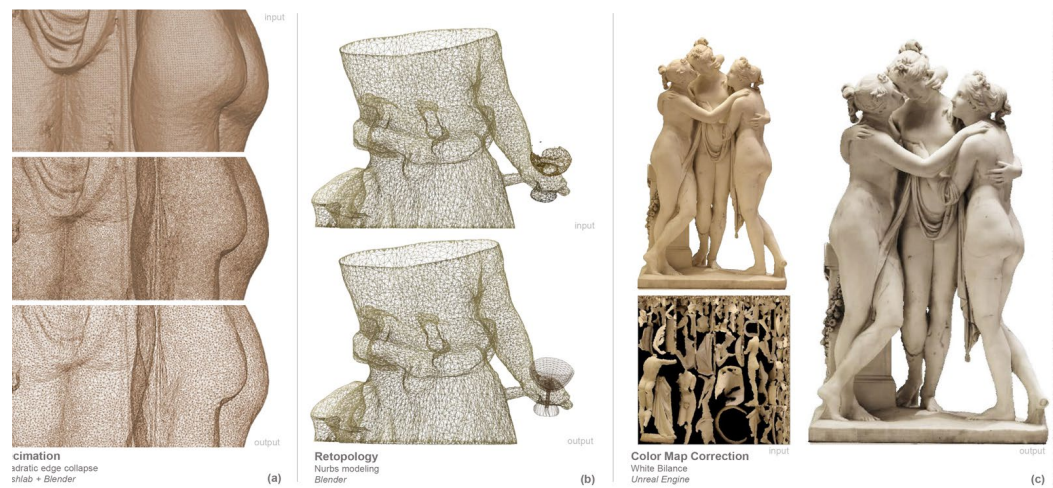Fig. 4. 3D Modeling. Results.

Fig. 5. Model manipulation for implementation.

The interactive experience was designed to simulate a visit to a virtual environment inspired by the original setting of the exhibition in the Meridiana Salon. In particular, the same floor was reproduced in the virtual setting, as it is a very recognisable feature of the real room. Also, the room colours were used to paint the virtual walls and the illumination system was designed to match the lighting of the room at the time of the survey. However, warm lights were used to light the statues, and so the colour textures had a strong yellow component. This effect was compensated by adjusting the white balance in UE4 (Fig. 5c).

Concerning the experience itself, the statues were positioned in the virtual room and each of them was associated with a virtual panel designed to show general textual information and

specific details about the statue. Descriptive texts were associated with the parts of interest and a virtual interface designed for the Oculus Rift controllers was implemented. Users could approach the statues and move around them as in a real setting. Moreover, hot points on the statues marked the presence of textual content that could be accessed by pointing and clicking. The room has also been provided with a virtual screen that showed different kinds of accessory material, together with the descriptions of the statues (Fig. 6). (V.C., A.O.)
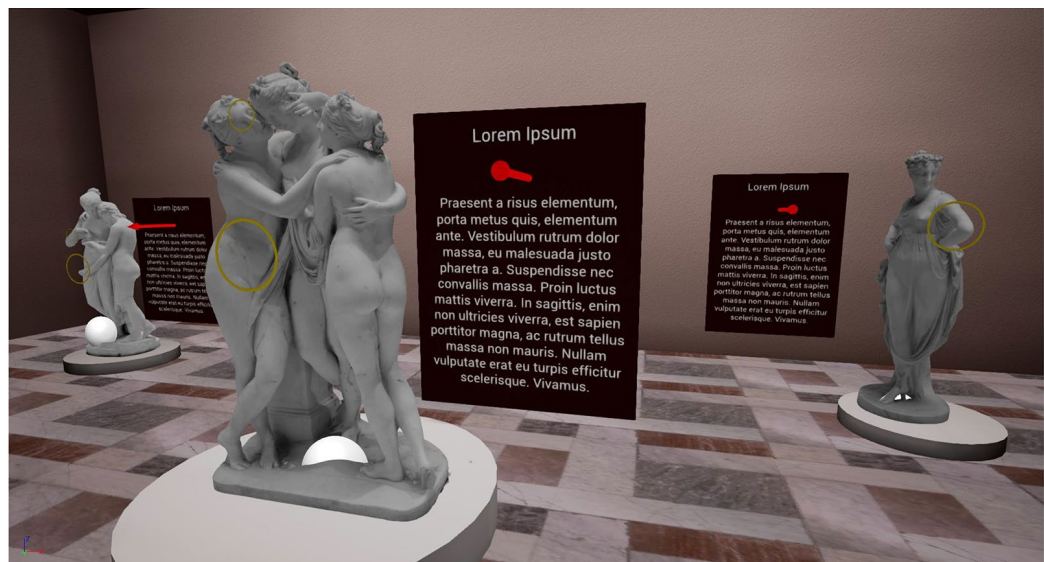

Fig. 6. Virtual scene.

Conclusions

The scientific collaboration between the Interdepartmental Research Centre Urban/Eco of the University of Naples and the MANN – National Archaeological Museum of Naples has provided the chance to realize an active example of digital museum. There, cultural and formative experiences related to the fruition of architectural and artistic artifacts can be relived over time, even if the manufacts are not physically and/or temporally located in the space where the experience takes place.

The implementation of the project has called for a strong degree of interdisciplinarity, as the required skills range from real digitization processes to the computer structuring of virtual environments. The paper also highlighted the need to carry out specific studies on the exhibition venue of the virtual experiences. In fact, the spatial composition of the digital environment where the statuary was located and its related visual perception were studied through specific activities: the study of colours in the hall, the analysis of materials of the pavement and walls, the study of light.

The strong goal of the concrete realization of an experience open to public has led to the Virtual Canova exhibition, which will be inaugurated in the summer of 2022 at the Educational Centre of the MANN. (V.C.)

Attributions

Although part of a shared work, in writing this contribution Francesco Cutugno (F.C.) has dealt with the paragraph: *Canova and the Future: the Virtual Canova project*; Valeria Cera (V.C.) has dealt with the paragraphs: *The digitisation project: container and content*; *The design of the VR experience*; *Conclusions*; Antonio Origlia (A.O.) has dealt with the paragraph: *The design of the VR experience*; Paolo Giulierini (P.G.) has dealt with the paragraph: *Canova and the Ancient: the exhibition*.

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