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Scientific investigation of *The Conversion of St Paul* painting (Mdina, Malta)

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Abstract – **The paper presents the results of two different approaches applied to the newly-restored painting *The Conversion of St Paul*, the main altarpiece in the Cathedral of Mdina in Malta. This large, dramatic painting is work of the Baroque artist Mattia Preti, *il Cavaliere Calabrese*. As is normal with a professionally executed restoration, several scientific methods have been used before, during and at completion, in the framework of a global analytical strategy. In particular, we focus on the results of the digital photogrammetric survey which uses image-based approaches for 2D/3D models reconstruction enormously. The model was used to quantify and measure important features on the painting as well extensions of areas restored. In addition, portable Raman spectroscopy was used to identify, in non-destructive way, the nature of the painting materials with the final goal of reconstructing the color palette of the artist.**

I. INTRODUCTION

The use of scientific methods to help the restoration of artifacts is attracting much more interest in the recent years [1-4]. On one hand, as testified by the increasing number of recent publications regarding 3D documentation and reconstruction [5], the use of software and techniques to reconstruct digital models of the artifacts has grown significantly in order to provide useful tools for conservation, cultural heritage documentation as well as integration of scientific analysis and results. In particular, the possibility to generate very accurate and detailed 2D/3D digital models from imagery is a great opportunity and several tools are available. On the other hand, Raman spectroscopy represents a well-established method that, through the non-destructive molecular identification of pigments and minerals, allows to answer to several questions related to provenance, dating, and manufacture technology of a variety of findings [6]. In this paper, we present the main results from two different approach, digital photogrammetry and *in situ* Raman spectroscopy, used for reconstruction purposes and for pigments characterization respectively, in order to help the restoration of the titular painting entitled *The Conversion of St Paul* and located above the main altar at St Paul's Cathedral in Mdina (Malta) [7]. The painting is quite large measuring 533 cm x 310 cm. It was painted by Mattia Preti in 1682 and commissioned by the Knights of the Order of Malta. *The Conversion of St Paul* is part of the series of miracles and mysteries of St Paul on Malta. This was the subject of a major cycle of paintings, executed by Mattia Preti during the last decades of the XVII century and of his life. The original painting is perfectly rectangular and it was created by joining three pieces of canvas of equal sizes and most probably made on the Maltese islands.

The painting, given also its size, can be considered as the master piece among the work done by Mattia Preti during his long activity in the Maltese archipelago. This master piece describes the moment in which the young roman soldier, Saulo, on his way to Damasco, was thunderbolt by Christ vision remaining blind for three days subsequently to a fell off from the horse.

II. DATA AQUISITION AND PROCESSING

The modern technological solutions offer great opportunities of having complete geomatic surveys in several environments [8] as well as in Cultural Heritage sector [2, 9-11]. As regards the acquisition phase of the metric data, both for the representation of objects of archaeological, artistic and architectural interest. Photogrammetry can be defined as a science to obtain reliable information about the spatial properties of land surfaces and objects, without physical contact [12]. Photogrammetry is a relatively new technique for accurate digital capture of 3-dimensional objects and surfaces. This technique is always more and more popular among the conservators community and it has been adopted for cultural heritage providing a set of new tools for archaeologists and cultural heritage experts. It has the great advantage to capture, store, process, share, visualize and annotate 2D/3D. Fig. 1(a) reports the workflow adopted to obtain the final digital model for *The Conversion of St Paul* painting of Fig. 1(b). It consists of several phases of processing. The first one (steps 1 and 2 in Fig. 1(a)) is the camera capture and alignment, which allows to correctly position the images with respect to each other and/or to calculate the exact position in the real space. It is at this stage that the software generates a sparse point cloud. The second phase (step 3 in Fig. 1(a)) involves the generation of a dense point cloud based on the estimated camera positions. The dense cloud of points can be modified if necessary before proceeding to the generation of the 3D mesh model. The third stage (step 4 in Fig. 1(a)) is the reconstruction of a 3D polygonal mesh representing the object surface based on the dense point cloud. After the mesh geometry generation and reconstruction, the model is textured and used for orthomosaic generation.

Raman spectra were collected by a portable 'BTR 111 Mini-RamTM' (B&W Tek, USA) spectrometer with an excitation wavelength of 785 nm (diode laser), 280 mW maximum laser power at the excitation port, and a charge-coupled device (CCD) detector (thermoelectric cooled, TE). In addition, the laser output power can be continuously adjusted by allowing to maximize the signal-to-noise ratio minimizing the integration time. The system is equipped with a fiber optic interface for convenient sampling. The excitation laser emits from the probe's end where the Raman signal is then collected from the sample. The spot size is 85 μm at a working distance of 5.90 mm. The maximum power at the samples was ~ 55 mW. All spectra were registered in the wavenumber range from 60 cm^{-1} to 3150 cm^{-1}, by using an acquisition time of 40 s and a resolution of 8 cm^{-1}, accumulating several scans for each spectrum in order to improve the signal-to-noise ratio. Each spectrum has been processed by subtracting the blank spectrum; in addition, a smoothing process has been performed by using the BWSpec 3.27 software.

The collected Raman spectra were compared with data from databases and the literature [13,14].

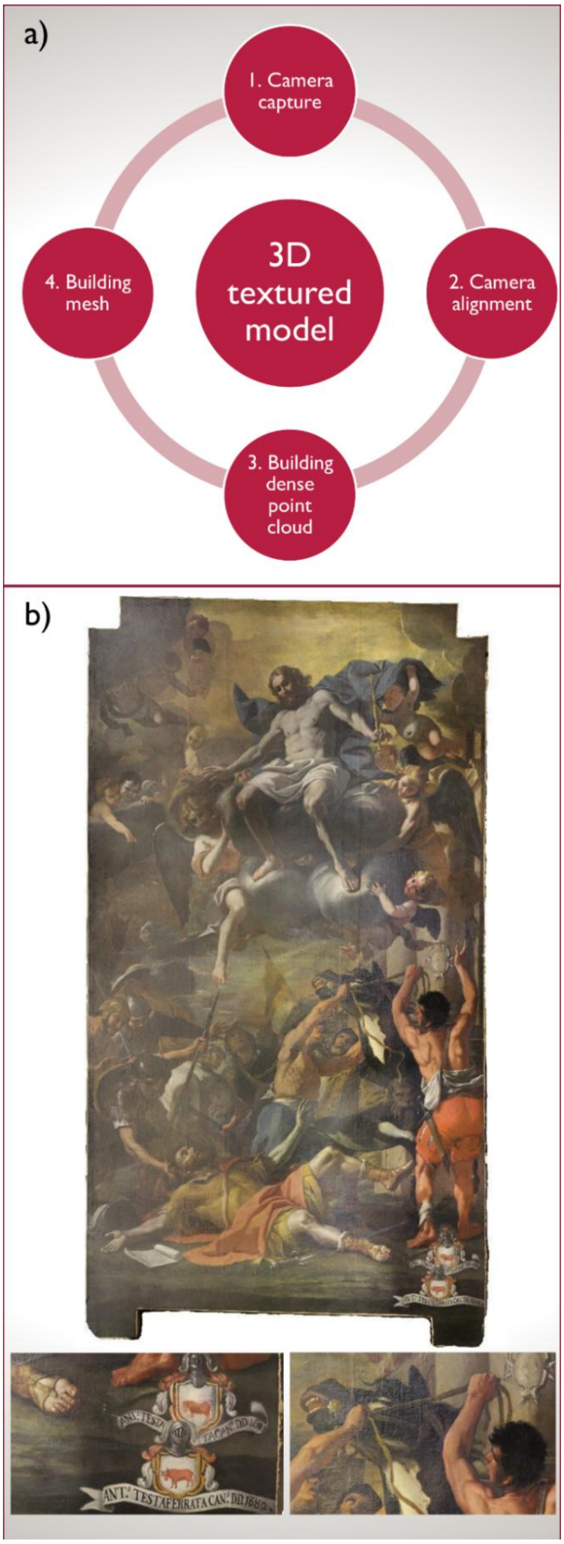

Fig. 1. (a): workflow used to create the digital model. (b): digital model of the painting and two particulars which show the high definition and details of the digital model.

III. RESULTS AND DISCUSSION

The digital model of the painting allows with high precision to have measurements of the whole artifact as well as of selected part of interest. Fig. 2 shows an example of measurements of an area as well as the measurements of distances between selected points.

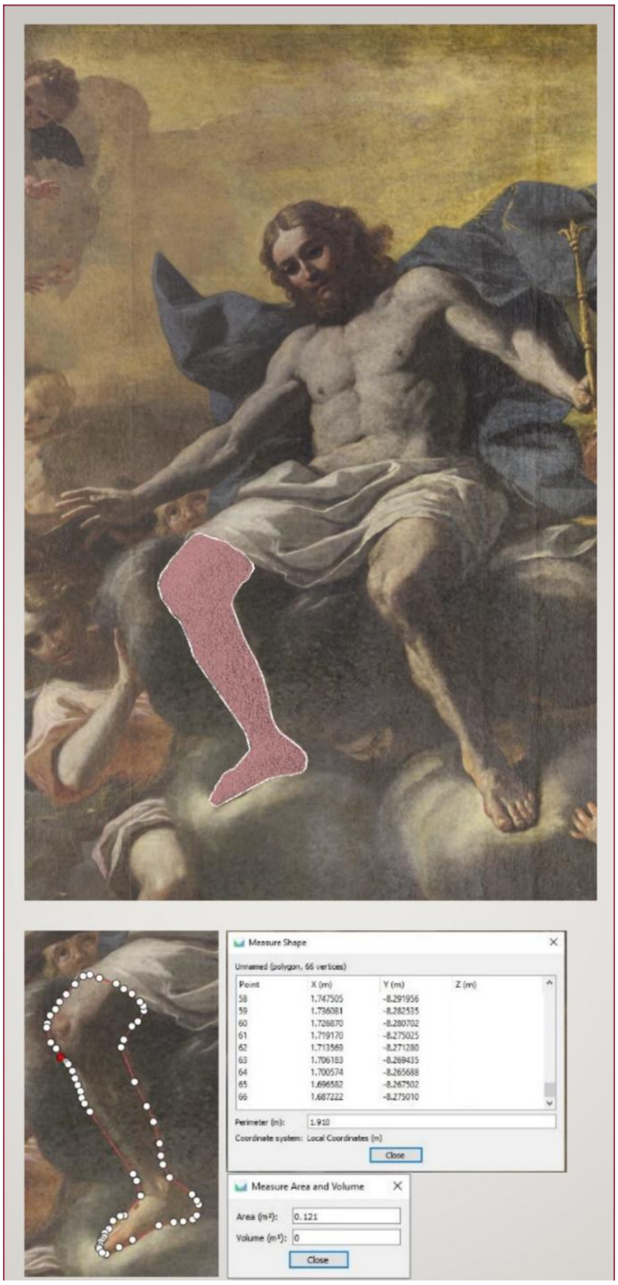

Fig. 2. Example of measuring areas and length on selected portions of the painting.

This is an extremely useful tool both in pre-restoration phase and for further studies and investigations. In fact, such approach could help historians and conservator to plan any necessary intervention or to study details of the painting by using the digital model and without touching or directly interact with the artifact. Furthermore, the digital model can be used for mapping purposes, as done in this study, by inserting on the digital model the points of measurements. It is also possible to create a digital repository of historical and scientific information that could be easily consulted remotely. Such tool and digital model can be combined with modern vision equipment bringing the painting into the virtual reality context, which has endless applications and uses.

As far as Raman measurements are concerned, the analysis of the red pigment was performed on points (a), (b) and (c) of the painting (see Fig. 3), representative of the areas of the reddish cloth of the lying soldier (a), of the red bull of the emblem located at the bottom right (b) and of the red robe of the soldier standing upright (c), respectively.

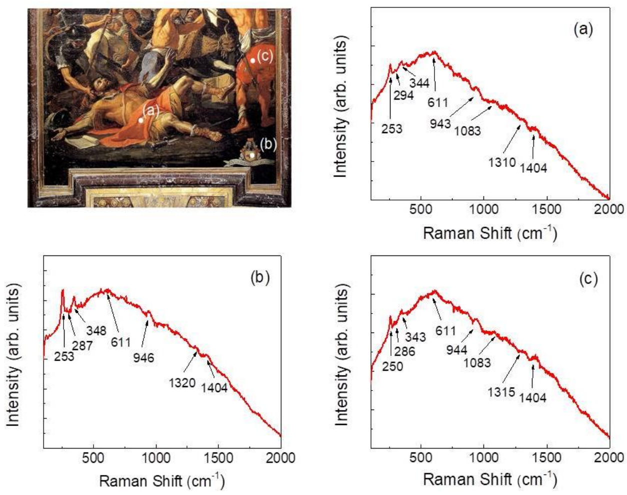

Fig. 3. Raman spectra recorded on three points (namely (a), (b) and (c)) representative of red pigmented areas of *The Conversion of St Paul* painting. (a): reddish cloth of the lying soldier, (b): red bull of the emblem located at the bottom right, (c): red robe of the soldier standing upright

As it can be seen, the three spectra show the presence of low frequency peaks respectively centered at ~ 250 cm^{-1}, ~ 286 cm^{-1} and ~ 348 cm^{-1} that can be ascribed to the presence of cinnabar (HgS), that can be retained as responsible of the intense red color. Cinnabar is a type of red mercury ore that was mixed with an equal amount of burning sulphur to create an expensive red paint, used since antique times for cosmetic and decorative purposes. Going on, the band at ~ 611 cm^{-1} can be associated with the presence of iron oxides, while the bands at ~ 943 cm^{-1}, ~ 1310 cm^{-1} and ~ 1404 cm^{-1} can be ascribed to the presence of organic compounds deriving, presumably, from the use of ligands of natural origin. Finally, for the spectra in Fig. 3(a) and (c) it is possible to observe the ~ 1083 cm^{-1} band indicative of the presence of calcite ($CaCO_3$), probably due to the preparatory layer, or used for lightening. The investigation of the white pigment was carried out on point (d) of the painting (see Fig. 4), as representative of the area of the white band of the soldier standing upright. The spectrum reveals the presence of the strong and sharp Raman band at ~ 1050 cm^{-1}, typical of lead white ($2PbCO_3 \cdot Pb(OH)_2$), that represents the main white pigment of European "oil on canvas" painting. Actually, as reported in literature [15], the presence of this band testifies a degradation state of this pigment. Going on, contributions at ~ 946 cm^{-1}, ~ 1304 cm^{-1} and ~ 1404 cm^{-1} may be due to the presence of organic components.

Finally, calcite is observed, by its typical contribution at ~ 1084 cm^{-1}. It is worth remarking that calcite is found to be often associated in paintings with other white pigments, such as lead white, in order to modify the rheological and optical properties of their paints [16].

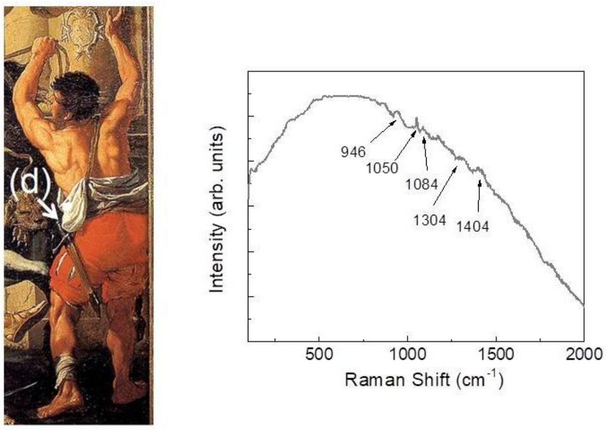

Fig. 4. Raman spectra recorded on a point (namely (d) representative of a white pigmented area of *The Conversion of St Paul* painting. (d): white band of the soldier standing upright.

IV. CONCLUSIONS

In the present paper, a non-invasive, *in situ* investigation was performed on *The Conversion of St Paul* titular painting by the Calabrian artist and Knight Mattia Preti. In particular, the study was aimed at showing the potentialities of the combined use of 2D/3D photogrammetric surveys and Raman spectroscopy in order to, on one side, get reconstruction, and, on the other side, achieve the identification and the characterization of the pigments of this wonderful painting that can be admired at St Paul's Cathedral in Mdina, Malta. This combined approach was successfully applied as part of the scientific analysis carried out before, during and at completion of the recent restoration of the painting. Nevertheless it appears promising, other than in research, preservation and restoration activities, also in improving promotion, dissemination, and accessibility in the field of cultural heritage. This research also served as a proof of concept and the next goal is to study in depth the several painting by Mattia Preti.

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