RAPID APPROACH OF INTEGRATED SURVEY FOR THE CONSERVATIVE ANALYSIS OF PICTURES.

D. Costantino, M. G. Angelini, G. Caprino

DIASS - Technical University of Bari; Viale del Turismo, 8 – 74100 Taranto (Italy); phone: +39 99 4733215, d.costantino@poliba.it

Commission VI, WG VI/4

KEY WORDS: Cultural Heritage, Photogrammetry, Thermal, Analysis, Classification, Interpretation, Test

ABSTRACT:

The survey and deep knowledge of cultural heritage and of its conservation state contribute to the definition of environmental sustainability criteria since the preservation of the cultural heritage is one of the fundamental aspects of this concept. In order to monitor the conservation state of a cultural heritage, it is necessary to acquire a series of data referred to the heritage and to the environment where it is placed, by developing elaboration functions able to provide evaluation elements, thanks to the support of integrated technologies and methodologies.
The diagnostic analysis constitutes a fundamental prerequisite for the elaboration of any kind of intervention of restoration in architectural, artistic and archaeological framework.
The subject was the picture of Jesus Crucifixion, in the sanctuary of Cristo la Selva in Matera, on which were applied different types of data and non invasive integrated survey techniques.
The knowledge and the study of the interaction environment-structure-artefact, was fundamental to evaluate the processes of degradation though the analysis conducted on the wall painting. Indeed, the environmental context around is the key to the reading of the objects conservation state. We made topographic and laser scanner surveys of the whole site for the reconstruction of the site itself and the study of the rooms and of their spatial allocation. Afterwards survey and integrated analysis techniques have been applied also on the paintings.
It was attempted to apply some quick criteria for the analysis of the degradation and the evaluation of the conservation state of the paintings. photogrammetric, thermal, laser scanning and topography data were used, integrated with the installation of temperature and humidity sensors on site.
The study is aimed at the definition of a rapid methodology to support further phases of sampling and analysis by focusing on the areas where a necessity of intervention or restoration has been previously detected.

1. INTRODUCTION

1.1 Rocky civilization in Matera

The Murgia of Matera keeps the most attractive remains of the rocky civilization today present in Italy. Indeed, due to both its geological formation and its typical urban structure, Matera is considered one of the most important centres of the rocky civilization from the Palaeolithic period up to now. The Murgia preserves many other examples of coenobies, as, for example, Ofra, Saint Eustachio, Saint Nicolas all'Annunziata. Among the above list, the coenobium of Cristo la Selva is the most complete and the most refined both for its architecture (the external front dates back to the XI century), and for the grandiosity of the whole complex and for the available services (for example the network of small channels carved in the rock which were useful to collect the rain waters into the storage tanks). The frescos that adorn the rocky Churches of the Province of Matera constitute an evidence of the high degree of culture reached by the monastic communities who lived there in throughout different eras. We are speaking about purely popular paintings, whose aim was, without any doubt, to elevate the spirit of believers. Even though the paintings were left in a state of abandonment, some lucky circumstances allowed to preserve most of them [T89] [T91].

Figure 1. Site of Cristo la Selva

During the last years, the attention has been addressed to the recover of the artistic and historical heritage of Matera contributed to its valorization, also in consideration of the obtainment of the degree of UNESCO Humanity Heritage in 1993. Yet, even though many restoration interventions on living units have been made by privates, few effort has been spent for the painted rocky churches and moreover, during the last thirty years, following to the re-discovery and re-opening of the hypogeous sites, the conservation state of the rocky wall paintings has worsened because of the break of the delicate micro-clima balances, which had guaranteed their survival for centuries. For the above reasons many of the wall paintings have disappeared, yet those which remain provide a collection of precious information, first of all with regards to the executive technique

1.2 The painting of Cristo la Selva

The painting of Cristo la Selva has probably been made as a fresco on a thin plaster (of different thickness due to the irregular rock surface), composed by "tufina" and lime in direct contact with the tuffaceous rock into which crypts are carved [RCT03].
The style of the painting is Byzantine and its date is referable to 1600. In effects, also preserving the canons of Byzantine style, characterized by the two-dimensional look of the painting (without light and shade effects), the Christ does not present any more triumphant appearance, but closer to the rebirth of the western world that changes the figure from the erect representation with open eyes to that suffering and relaxed in the death with bent head and closed eyes. The same evolutions are also evident in the anatomical study of the body, still symbolized in two-dimensional way through precise signs of colour and moreover through the posture of the body that gets the idea of space between the Cross and Christ. In the painting there are also present the first Gothic aspects noticed through the elegance of the bust and the expressions of the face (fig. 2).

Figure 2. The painting of Cristo la Selva

2. METHODOLOGY OF SURVEY

2.1 Laser scanner survey

A laser scanner survey of the whole site was performed with the purpose to derive its three-dimensional reconstruction. This result allowed to represent metrically a site of complex nature which is not easy to measure in its completeness through the aid of other techniques. [CCR*05] [CCA05].
The results (fig. 3-4), here follow represented, show the 3D eyesight of the site and its spatial conformation. There were also derived plans that represent the temporal and spatial development of the site (fig. 5).

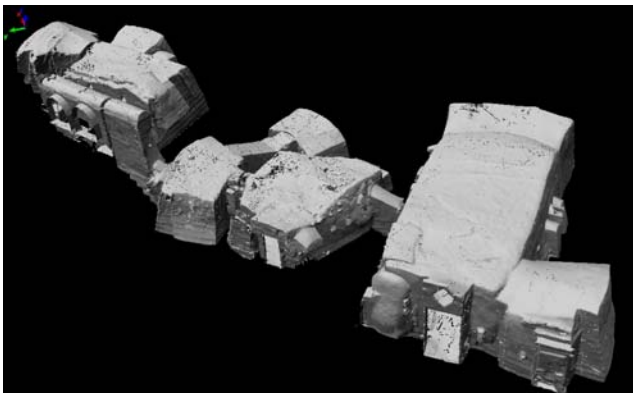

Figure 3. 3D model of the Cristo la Selva church interior

Figure 4. 3D model of the Cristo la Selva church

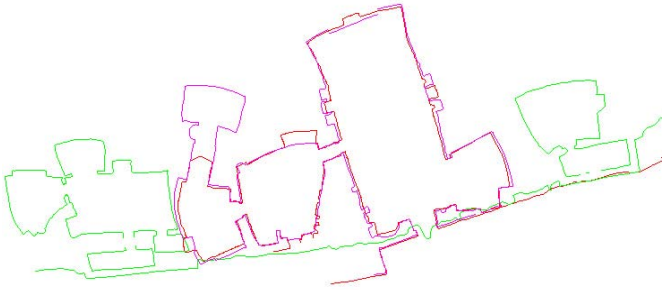

Figure 5. Plan of the church

Subsequently, a laser scanner survey was performed, set only on the painting of the Christ, built through a 1mmx1mm grid and to a 5-meter probe (fig. 6).

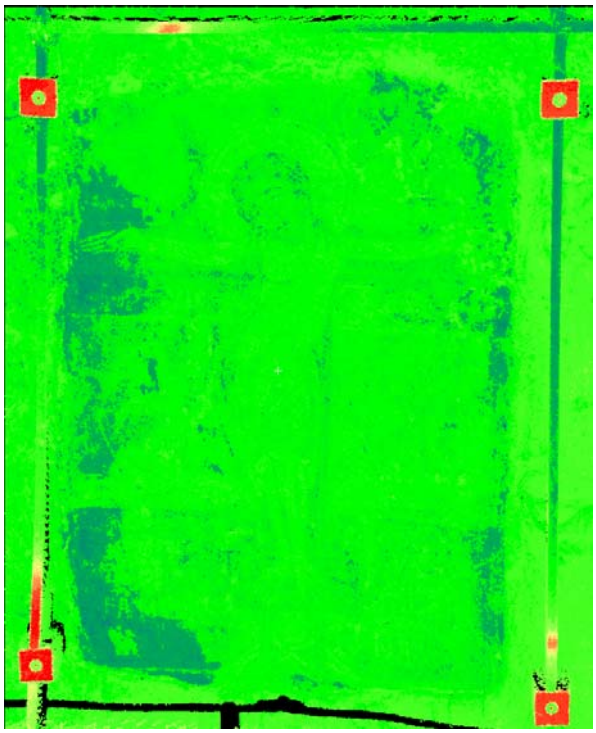

Figure 6. Laser scanner Survey

-5.042252	2.311905	-0.042435	0.482643	22	26	25
-5.018265	2.300858	-0.010178	0.485206	25	27	26
-4.993851	2.289597	0.021744	0.487892	16	20	19
-4.967545	2.277481	0.053421	0.488869	27	31	30

Figure 7. File ptx of reflectance information

This survey was executed to get the 3D reconstruction, used as basis for georeferencing all the other information of geometric nature and for analyzing the non-direct datum coming from the instrument, that is the one referred to the material reflectance.
In particular, the laser scanner instrument used is the HDS3000 at Time Of the Flight (TOF), which provides not only the spatial coordinates of each point belonging to the scanned cloud, but also its reflectance value.

2.2 Photogrammetry Survey

The photogrammetric survey was performed with a calibrated digital camera NIKON D1.
Firstly, the procedure of camera calibration (fig. 8) is performed through techniques and already known methodologies [XZZ04] [FTR02] [LW91], subsequently the photogrammetric captures were taken.

CAMERA: NIKON D1 S/N 5018608 - Obb. 24mm S/N 477521

Posizione di messa a fuoco: iperfocale
Dimensione dell'immagine: 2000 x 1312 (23,7mm x 15,5472mm)
Dimensione del pixel (in micron):
Distanza principale autocalibrata (in mm): 24,8210

Distorsione radiale media

R1(mm)	R2(pix)	D1(micron)	D2(pix)
0,00	0,00	0,00	0,00
1,00	84,39	-5,01	-0,42
2,00	168,78	-13,99	-1,18
3,00	253,16	-15,80	-1,33
4,00	337,55	-21,92	-1,85
5,00	421,94	-23,75	-2,00
6,00	506,33	-27,97	-2,36
7,00	590,72	-36,38	-3,11
8,00	675,11	-44,84	-3,78
9,00	759,49	-55,96	-4,72
10,00	843,88	-74,99	-6,33
11,00	928,27	-111,84	-9,44
12,00	1012,66	-126,87	-10,71
13,00	1097,05	-167,95	-14,17
14,00	1181,43	-192,97	-16,28
15,00	1265,82	-242,99	-20,51

R1: Distanza dal centro in mm
R2: Distanza dal centro in pixel
D1: Distorsione in micron
D2: Distorsione in pixel

Posizione del punto principale

	in pixel	in micron
xp=	987,86	11706,14
yp=	653,01	7738,17

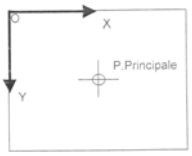

Figure 8. Calibration parameters

As visible in figure 9, there were materialized some points of support belonging to a metallic grate positioned on the painting. Through these points (recognizable in the photogrammetric image and in the laser scanner survey as well as in thermographic image), and other natural points, the processes of photogrammetric elaboration were run.
The photogrammetric data provided both the images necessary for a visual analysis of the object (to compare with other obtained results) and the metric restitution through the production of ortophotos.

Figure 9. Photogrammetric Image

2.3 Thermical Survey

The thermal images were realized through Standard NECs version 7800 1.4A instrument (fig. 10) with sensor: 7100, dimension DX (0-319) DY (0-239).

Figure 10. Thermical instrument

The wall with the painting was heated through electric resistance reaching a temperature of around 50° Celsius. The characteristic parameters of the phases of survey were measured through Hygrothermometric sensory (Babuc M/A), necessary to acquisition, visualization, storage and elaboration of a big variety of physical and chemical attributes such as temperature, humidity, air speed, pressure, illuminance, gas, noise, etc. The thermal images allowed to analyse the external sub-surface structure throuugh the comparison between the result before and after the heating, artificially provoked by thermo-convention, and to extract information corresponding to superficial differences and discontinuities, anomalies, defects and/or peculiarities invisible to the naked eye.

3. ELABORATION AND RESULTS

3.1 Elaboration of the data

The whole set of data, surveyed through the different techniques previously described, was georeferenziated in the reference system associated through topographic technique of survey to the targets materialized on the image. This allowed to reach, at the end of the processes of elaboration described later, the overlap of the images and the comparison of the recovered elements. On the laser scanning, particularly on the image of reflectance deduced by the survey, it was performed, through the Envi software, a classification unsupervised by defining nine classes through the K-means parameters (fig. 11).

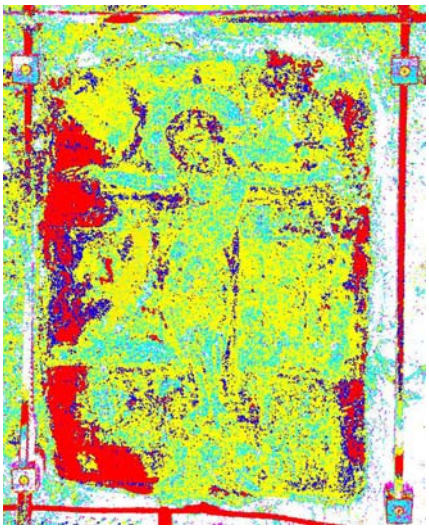

Figure 11. Classified image

Through the reading of the results and the overlap of this image with the photogrammetric one it was possible to compare the actual results. It is necessary to emphasize that the photogrammetric images were taken under different environmental conditions, or under conditions of absence of humidity of the site and after repeated showers happened in the region (fig. 12). Moreover, there was a comparison between the results of interpretation from laser and photogrammetric image with those deriving from the elaborations of the thermal images, by mapping the present characteristic phenomenona. In fact, there were pointed out the common regions in which, through a quick analysis, it was possible to discover and to highlight present elements.
Some of these elements are detailed as follows.

Figure 12. Dry and wet image

On the images the phenomenona were named through the letters A) B) C) D) E) (fig. 13-14).

A) Present in both the photographic image and in the laser one, it represents the grade of imbibition of the painting; in such points it was discovered the maximum gradient of humidity and temperature. It can also be observed that such phenomenon, also existing on the superior area of the painting, is not found by the classified laser datum, and it is more likely imputable to the imperfect perpendicularity of the laser ray with respect to the object.

B) This phenomenon, also present in the laser image and RGB one, seems to be caused by the presence of mold e/o bacteria.

C) It represents a supply element modified in the centuries, or an intervention of improvement, started after a phenomenon of detachment of a small area of painting, which was executed by using obsolete and handicraft procedures of restoration (fig. 15).

D) This element, found in all the types of data, is imputable to the simple separation and loss of materials.

E) More interesting is such phenomenon that represents an element of discontinuity in the rocky structure, actually, it is not influenced by the capillarity of the water (fig. 16).

Figure 13. Wet Image with underlined phenomena

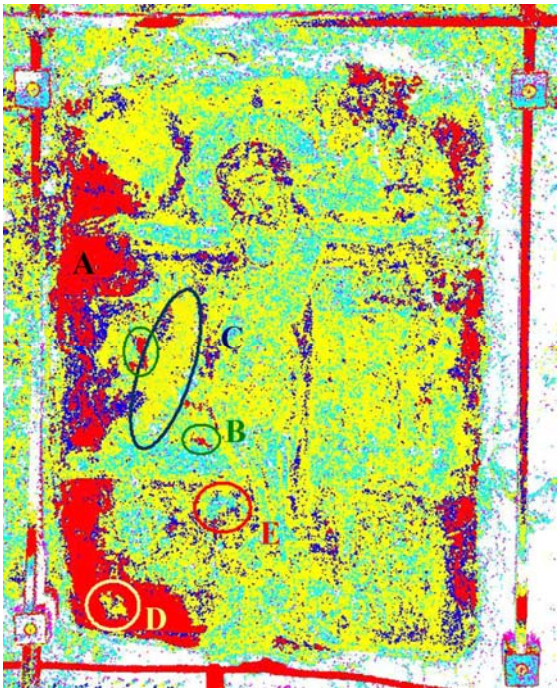

Figure 14. Classified laser image with underlined phenomena

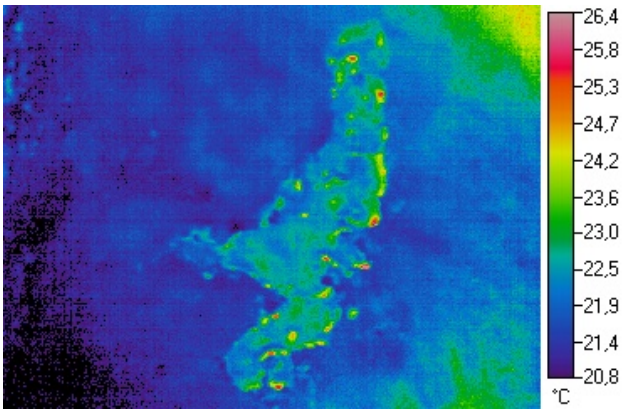

Figure 15. Thermal image with particular of C) phenomenon

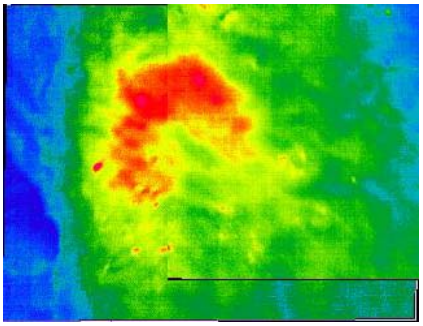

Figure 16. Thermal image with particular of E) phenomenon

4. CONCLUSIONS

The used techniques have only the intention to provide a quick and rough methodology to detect and to identify on site phenomena of alteration on paintings and frescos. Within the developed work, it is suggested to keep on such activity, by improving it and by trying to find a standard and repeatable methodology of approach, whose characteristic fits both the type of painting and the objective of investigation. The integration of techniques, not properly devoted to the renovator, gives assist and support to his work at least in the first phases of investigation. The preserved metrics in the different elaboration provide additional data of analysis for the interventions of restoration.

4.1 References and/or Selected Bibliography

References from Books:

[T89] Tommaselli M., 1989– *"Il parco della Murgia", Guida all'escursione* – , edizione Giannatelli.

[T91]Tommaselli M., 1991 – *"Chiese rupestri di Matera e del suo territorio"* –, Capone editore.

[RCT03]Rota L., Conese F., Tommaselli M., 2003 – *"Storia di una città"* –, ED. BMG Matera.

[E01]El-Hakim S. F., 2001 "*Three-dimensional modelling of complex environments*", SPIE Proc., vol. 4309, Videometrics and optical methods for 3D shape measurements, San Jose.

[CC07] Capra A., Costantino D., "*Geomatica – per Corsi di Laurea e di Laurea Specialistica (Magistrale)"* - 2007 – Mandese Editore

References from Journals and Other Literature:

[CCR*05] Capra A., Costantino D., Rossi G., Angelini M. G., Leserri M. – "*Survey and 3d modelling of Castel del Monte*", CIPA 2005 XX International Symposium "International Cooperation to save the world's cultural heritage" pp. 183-188, Torino 27/09/2005.

[CCA05] Costantino D., Capra A., Angelini M. G. – "*Virtual reconstruction of damaged decorative elements*", Workshop Italy-Canada 2005 "3D Digital Imaging and Modeling: Applications of Heritage, Industry, Medicine and Land", Padova 17-18/05/2005.

[CRA*05] Costantino D., Rossi G., Angelini M. G., Leserri M. – *"3D Modelling for the Urban Area "Porta Napoli""*, CIPA/VAST/EG/EuroMed2006 "The e-volution of Information Technology in Cultural Heritage. Where Hi-Tech Touches the Past: Risk and Challenges for the 21st Century", ISBN 10-9638046-75-9, vol. Project Papers, pp.79-85, Nicosia- Cyprus 30/10-04/11-2006;

[XZZ04] Xie W., Zhang Z., Zhang J. - *"Multi-image based camera calibration without control points"* XXth ISPRS Congress, 12-23 July 2004 Istanbul, Turkey Commission 5

[FTR02] Fengjun Lv, Tao Zhao, Ram Nevatia, 2002. Self-Calibration of a camera from video of a walking human. *International Conference on Pattern Recognition*, Quebec City, Canada, pp. III: 639-644

[LW91] Ling-Ling Wang, Wen-Hsiang Tsai, 1991. Camera calibration by vanishing Lines for 3-D computer vision. *IEEE Transactions on Pattern Analysis and Machine Intelligence.* Vol.13,No.4

4.2 Acknowledgements

Gianni Abate - Leica Geosystems S.p.A.
Dott. Cesare Passarelli that owns the cite