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THE RECONSTRUCTIVE STUDY IN ARCHAEOLOGY: CASE HISTORIES IN THE COMMUNICATION ISSUES

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Abstract

The most significant results obtained by Information Technologies Lab (IBAM CNR - ITLab) in the construction of VR-based knowledge platforms have been achieved in projects such as ByHeriNet, Archeotour, Interadria, Interreg Greece-Italy, Iraq Virtual Museum, etc. These projects were guided by the belief that in order to be effective, the process of communicating Cultural Heritage to the wider public should be as free as possible from the sterile old VR interfaces of the 1990s. In operational terms, this translates into solutions that are as lifelike as possible and guarantee the maximum emotional involvement of the viewer, adopting the same techniques as are used in modern cinema. Communication thus becomes entertainment and a vehicle for high-quality content, aimed at the widest possible public and produced with the help of interdisciplinary tools and methods. In this context, high-end technologies are no longer the goal of research; rather they are the invisible engine of an unstoppable process that is making it harder and harder to distinguish between computer images and real objects.

An emblematic case in this regard is the reconstructive study of ancient contexts, where three-dimensional graphics compensate for the limited expressive potential of two-dimensional drawings and allows for interpretative and representative solutions that were unimaginable a few years ago. The virtual space thus becomes an important opportunity for reflection and study, as well as constituting a revolutionary way to learn for the wider public.

1. The virtualization of archaeological items

Fixed archaeological items, unlike movable finds, cannot in most cases, be transported to a museum. By their nature, their fate is often quite different to that of movable items, which are catalogued, cleaned, studied, and carefully looked after, whether or not they end up on display in a showcase. Fixed archaeological items are often stripped of the most precious objects that they used to house, and even in the best-case scenario, i.e. when they are not looted before being excavated, they are typically restored in a hurry. A similar fate often awaits those sites which, due to specific problems of accessibility or the sheer impossibility of creating an adequate system for visiting them, are closed to the public and are frequently unheard of by tourists. In the ancient nuclei of many towns, these sites are like pieces of a puzzle that has become illegible; they pose serious problems of knowledge and documentation, in addition to problems related to monitoring their state of conservation, often compromised by their condition of semi-abandonment.

The numerous virtual itineraries constructed on the basis of computerised data by our laboratories constitute an attempt to describe processes of cultural exchange and assimilation

via a three-dimensional representation in which the role of the 'virtualized' item is not to provide a perfectly life-like simulation of reality, or even worse a hyper-realistic alternative to reality, but to be the starting point for the creation of an artificial world that enriches and decodes reality, obviously recreating it, but above all interpreting it. In accordance with this principle, this type of activity may fairly be described as the transformation of an item into a distance museum piece, starting from the restitution in digital form of all the elements that are necessary for the comprehension of given content. Digital models thus become the informational basis for the development of navigation platforms, in the most advanced cases in RealTime3D, which make it possible to view and enjoy these items at a distance. The utility and effectiveness of this process, which we have called "museographical", depends on how much information is transmitted to the final user, while seeking to "highlight" the value of the item with suitable communication tools and methods which are also appropriate to the users' various levels of interest and understanding.

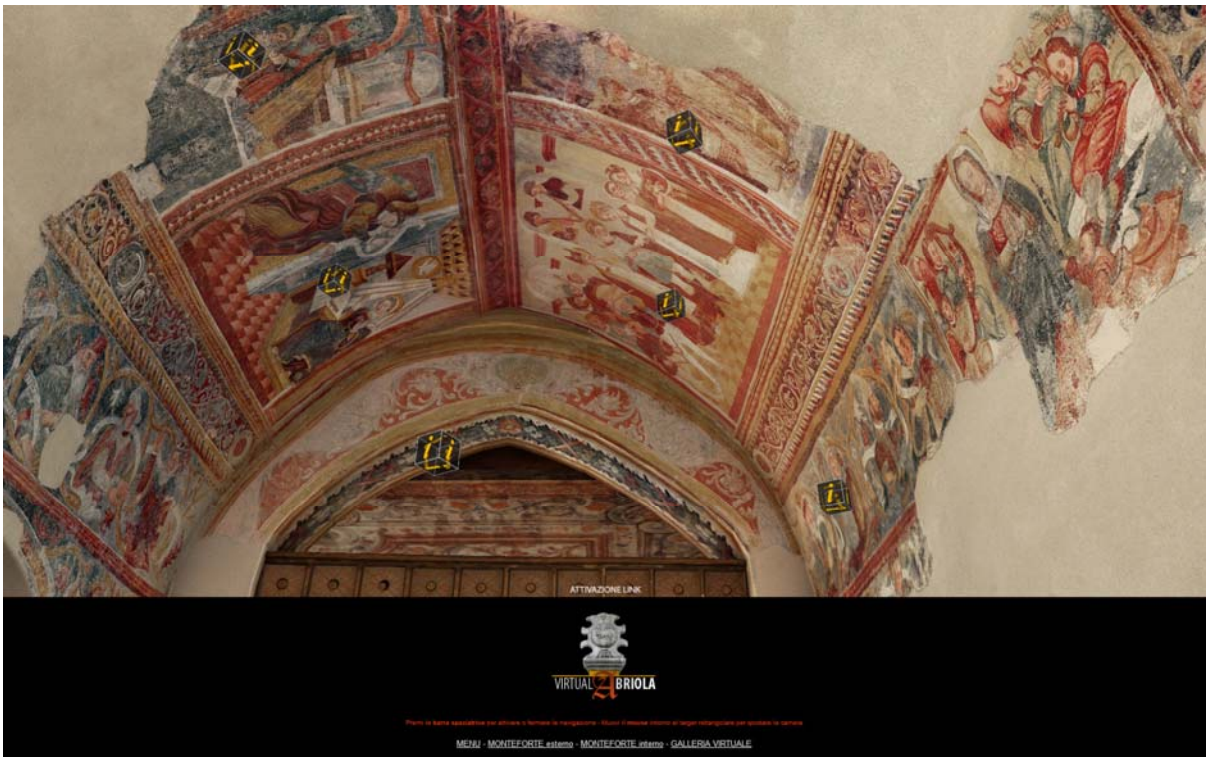

Figure 1: Screen-shot of Virtual Abriola, Realtime 3D platform for the distance visiting of Giovanni and Girolamo Todisco works. 3D model obtained by means of digital photogrammetry.

2. The experience gained in the ByHerinet project: digital photogrammetry or Laser scanning?

2.1 Objectives

The main objective in the context of the ByHeriNet project is the development of integrated methods for the creation of three-dimensional models using laser scanning techniques, photogrammetry and 3D photomodelling, applied to Byzantine sites in the province of Lecce and the region of Basilicata, with particular reference to those monuments with elements of special interest that are representative of the period in question. The three-dimensional models developed using the integrated methods described below provide a useful knowledge base for representing architectural morphology on various scales with great accuracy. This includes both specific details and the overall monumental arrangement, as well as the textural characteristics of the interior and exterior surfaces.

Each monument was modelled and studied in relation to its environmental context, noting its underlying system of relationships, which is often the key to understanding the architectural strategies adopted. The main goal of this research however remains that of allowing the public to benefit from the results obtained, either via the web or stand-alone products, so that they may “visit” and enjoy the monuments using both 3D RealTime visiting systems and spherical and interactive 3D panoramas. Each three-dimensional model is thus integrated in a multimedia authoring system in which all the data formats available for the item in question (RealTime 3D scenes, audio, video, VRML, QTVR, VR-Object, images, tables, etc.) can be combined in a single environment. Descriptions of an academic and critical nature (historical overview, relations with other ancient contexts, exegetical analysis, etc.) are combined with technical and scientific methods of analysis and diagnosis (e.g. analysis of constituent materials, state of conservation, study of architectural characteristics, etc.). In this interactive environment, it is possible to interact with the structures of the sites under study and search the associated databases for drawings of the layout, topographical data, orthophotos and historical documents, together with information on the mineralogical and petrographic characteristics of the construction materials, plasters and paintings. The virtual visit is further enriched with CG (Computer Graphics) reconstructions that provide the user with a diachronic reading of the monument and enable him/her to better understand the transformations it has undergone.

The process of creating content relating to each monument studied may be summarised as follows:

1. Gathering of the historical documentation available;
2. Architectural survey of the structures, performed with methods appropriate to the distinctive characteristics of each monument;
3. Three-dimensional restitution and optimisation of the models in accordance with the predicted outputs;
4. Extraction of the two-dimensional maps and video footage to be integrated in the computer vision systems or in the stand-alone publishing products (DVD Videos, VRML models, etc.)
5. Creation of interactive spherical panoramas (QTVR);
6. Implementation of the 3D models and QTVR contributions in VR knowledge platforms.

2.2 Strategies for the restitution of the monuments in their current state

From the outset, the research team tried to identify methods that were suitable for a faithful restitution of the actual state of the items on the various scales, with a view to their publication on Realtime 3D platforms. The first element in the identification of the appropriate method is the detailed analysis of the objects under study. In our case, the ByHeriNet project entails the study of two main monuments: the first is the abbey of S.M. di Cerrate (Squinzano, Lecce, Southern Italia), located inside a monastic complex, characterised by fairly regular architectural spaces and elements, with plastic motifs associated mainly with capitals and the main doorway. Given the monumental arrangement and the size of the site, architectural photogrammetry methods were considered best for the three-dimensional restitution. The second monument studied is a rupestrian church carved out of a steep rock face near the ravine of Matera, a UNESCO world heritage site. The church is entirely excavated from the rock and is characterised by a rather irregular and “organic pattern”, with hollows and bulges that testify to continuous alterations over the course of the centuries. The architectural space is characterised by a certain continuity of the surfaces. Consequently the geometry that can best represent it in 3D needs to be developed as a single mesh, with no juxtaposed elements. For this monument, laser scanning was held to be the only suitable instrument for the restitution. Both of the studied monuments are of the Byzantine epoch.

Figure 2: Santa Maria di Cerrate church (Squinzano, Lecce, South Italy), screen-shot of Realtime 3D platform.

Figure 3: Wireframe of 3D restitution based on digital photogrammetry

2.3 The Abbey of S.M. di Cerrate: photogrammetric approach

The Abbey of Santa Maria di Cerrate, situated in open countryside in the municipality of Squinzano, a few kilometres North of Lecce, was founded at the beginning of the 12th century by Norman counts. Its history is similar to that of many other Italo-Greek abbeys of the Salento peninsula. An important Basilian monastery, which was also the home of a famous scriptorium, the building was extensively modified in the following epochs, a wing with porticos being added to the original structure, along with a sumptuous sixteenth century well and other later additions. Typical of the Salento is the exterior decoration of the church with narrow pilasters and arches, while the rich 13th century portal reflects French tastes. The interior of the basilica was decorated with frescoes between the 13th and 16th centuries, as part of a long and continuous effort to beautify the building, which was a very important centre of religious and cultural life until the 16th century at least. Subsequently the complex was transformed into a masseria, a farmhouse, only recently re-emerging as a cultural point of reference for the area; the restoration of the church and of the surrounding buildings included the establishment of an interesting Museum of the Arts and Traditions of the Salento, under the control of the provincial museum.

The interior of the church takes the form of a basilica with three naves, of which the smaller one to the left is connected to the 12th century portico. The façade contains hanging arches that highlight the three-way division, framing two single-pane windows corresponding to the smaller lateral naves and separating the small rose from the richly decorated portal in the centre.

Figure 4: Santa Maria di Cerrate church (Squinzano, Lecce, South Italy), screen-shot of Realtime 3D platform. The external view.

Figure 5: Virtual reconstruction of the late ancient productive area in Egnazia (Fasano, Brindisi, Italy)

Figure 6: The kerameikos of ancient Metaponto (Basilicata, Italy)

Figure 7: The virtual reconstruction of Ninphaeum of Tritons in Hierapolis (Pamukkale, Turkey)

Figure 8: Reconstructive study of Neolithic settlement (S. Anna di Oria, Brindisi, Italy)

The aims of the architectural survey of the Abbey of Santa Maria di Cerrate are to document the current state of the building and construct the three-dimensional models necessary for the development of the knowledge platforms described above. Consequently, the survey operations concerned not only the individual surfaces of the church itself, but also the series of buildings that encircle the Abbey today in a "defensive wall" and form an inseparable part of the same monumental complex. Given this premise, the early phases the work focused on the acquisition of the basic photographic documentation and on the choice of appropriate techniques for the restitution of the monumental complex at a high level of detail and precision. As already mentioned, considering the aims of the communication products and the survey issues specific to this case, it was readily perceived that these requirements could be met by restitution techniques based on digital photogrammetry and photomodelling in particular.

The reasons for this choice obviously include their greater flexibility and ease of use compared to normal photogrammetric techniques, but above all the possibility they provide of obtaining three-dimensional models of great precision at very low cost. In this specific case, it should be stressed that the surveying difficulties resulting from the height of the buildings, together with the problems of accessibility to certain architectural elements (the rose, roofs, upper windows, etc.), mean that considerable effort (and additional costs) would

have been required for the deployment of the equipment necessary for a traditional photogrammetric survey. Given the conditions, the adoption of a system based on laser scanning was also excluded *a priori*, in that this would have required greater processing times in terms of post-editing and would have generated redundant data for the flat surfaces. In an architectural survey with specific aims such as this one, the key factor is the critical judgement of the surveyor, who must identify, by means of a careful analysis of the architectural elements, only the essential points necessary for the restitution. This critical evaluation, which entails the recognition of corresponding points in different photographic shoots, is also the fundamental task in photomodelling surveys. In operational terms, it is sufficient to identify the vertices of each architectural element, or insert some targets on the surface being surveyed in the poorly characterised areas, in order to obtain three-dimensional models complete with textures mapped in UVW projection.

The use of commercial software and a simple digital camera for the production of the single basic medium (digital photographs) necessary for the generation of the various contributions (3D models, QTVR) provides a method of reference for small-to-medium operational situations with low budgets. As well as the facility of use and the considerable results that any reasonably skilled operator can achieve in a photomodelling-based survey, this technique, as already mentioned, makes it possible to obtain three-dimensional models with a small number of polygons complete with textures. This characteristic is highly important, if one considers the use of these models as the operational basis for the development of communication products based on 3D metaphors. Every ‘desktop’ solution – and even more so every use on the web – requires models that are optimised for the best management on machines with that kind of hardware.

2.4 Issues linked to virtual restoration

The acquisition of data starts with knowledge of the current state of the item and entails the formulation of reconstructive hypotheses which are used to channel information, not only concerning what is directly observable in situ, but also and especially on those elements that are most difficult to read or decipher. This point represents the pre-condition for an interesting application of Computer Graphics to the representation and interpretation of a work of art for educational purposes: virtual restoration, understood as the digital reconstruction of the original image of the item with the help of all available forms of documentation. There is currently much debate on the theme of digital (or virtual) restoration,

especially concerning the numerous methodological implications that necessarily bind it to the discipline of 'modern' restoration, from which it was born. Modern restoration is founded on a basic principle: it must concern itself exclusively with the material aspects of the work of art, i.e. it must guarantee respect for its value as a historical and aesthetic instance and must limit itself to conservation of the materials of which the work itself is made.

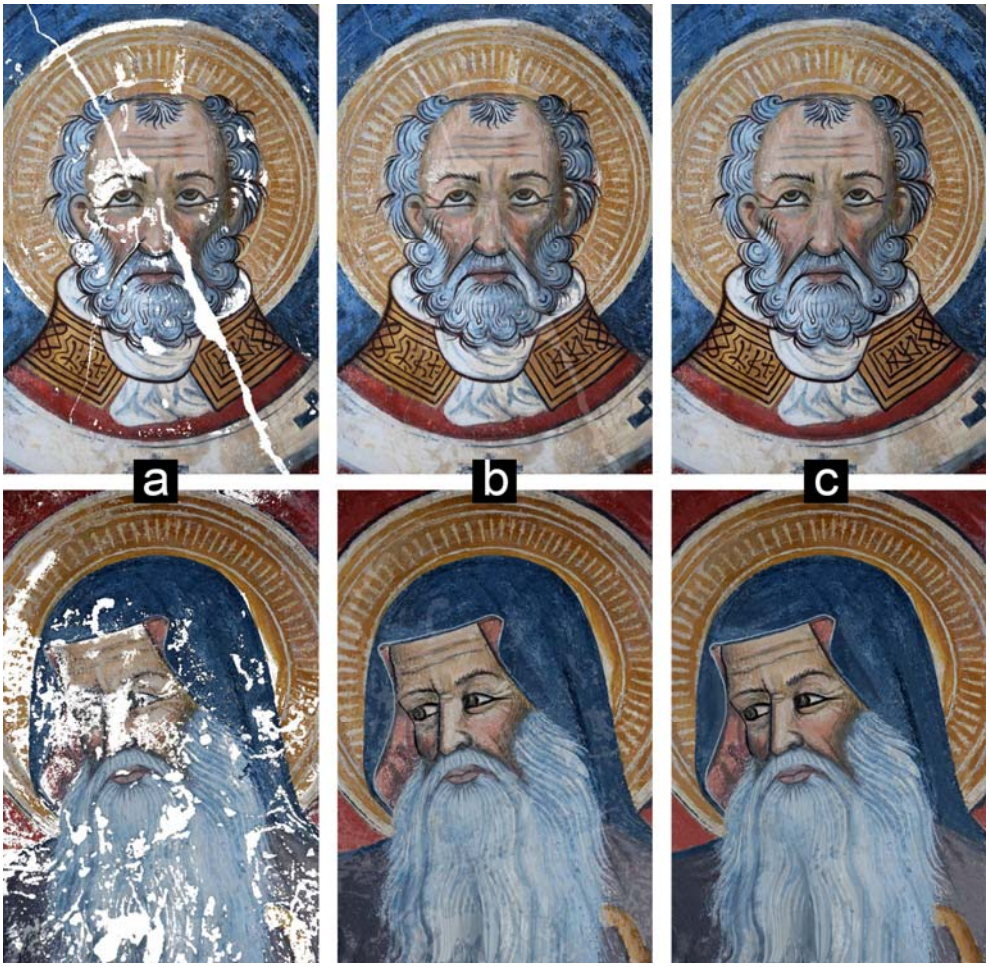

Figure 9: S. Stefano a Soleto church: a. actual state, b. virtual restoration, c. virtual reconstruction (thesis of M. Leo, Accademia di Belle Arti di Lecce)

The term 'virtual', i.e. potential (and thus neither current nor material) suggests that it is no more than a form of checking or verification *ex ante* of a hypothetical act of real restoration, and in no way could it be properly defined as 'restoration' itself. It is completely wrong however to think that the digital world is not material; on the contrary, the numbers, images, sounds and so forth that are produced on a computer are part of a new type of materiality, which has a physical consistency and its own domain of reference and circulation. Just like real objects, three-dimensional models have a measurable spatiality, they express physical

and chromatic values, they can be replicated ad infinitum or be transformed into 'tangible' objects by means of prototyping techniques; what is most important is that they exist. Digital restoration can plausibly serve as a guide in acts of real restoration, helping to check many critical aspects of the work; however, it can also take on a scientific value in its own right if it enables us to visualise the work as it appeared in a certain moment of its life, restoring its value as historical testimony to the civilisation that is exemplifies.

In the case study of S. Maria di Cearrate, the task of reconstruction concerned both the outside of the complex and the interior of the church, with particular attention paid to the problem of the Virtual Restoration of the frescoes visible today on the walls of the smaller naves. These frescoes are extensively pitted – the result of deliberate damage to the surface to ensure the adherence of a subsequent layer of plaster, which was covered with another cycle of frescoes, and which was removed during restoration. This layer is conserved today and viewable in the rooms of the adjacent museum. By means of virtual archaeology, or rather Virtual Restoration, these paintings have been re-collocated in their original position, above the more ancient frescoes; the user can thus view in a single product the chronology of the historical phases that have been documented and discover in a few minutes the historical evolution of the item over the centuries. Two distinct digital restoration techniques have been developed: the first was used for the re-composition of a fresco of the 13th century on the South wall of the church. As a result of numerous rebuilding episodes that involved the dismantling and subsequent reassembly of the wall, which was painted, in its current state it lacks iconographic consistency, and the reassembly makes this fresco something of a puzzle. Concerning the specific issues involved in the restoration of pictorial cycles, digital restoration is closely linked to all the operations that precede the drawing up of a conservation plan, in accordance with the so-called "guided restoration" approach. This provides a pre-visualisation of the hypothetical restoration measures, but more importantly it makes it possible to restore the legibility and formal unity of the work of art in all its figurative significance, while respecting the principles of modern restoration: distinguishability, reversibility, minimal intervention and compatibility.

The restitution of the fresco entailed firstly a series of photographs using a special support, targeting individual parts of the fresco with the use of photogrammetric techniques. Subsequently, all the parts were digitally re-collocated in a single high definition photograph. The result obtained enabled the partial restitution of the fresco and the creation of a texture that was subsequently applied to the 3D model of the church in its 13th century phase. Other

cases of digital restoration of pictorial cycles involved the re-collocation of two late-medieval frescoes removed during the restoration of the church in 1970. These are today conserved in the adjacent museum. In this case too, high resolution photogrammetric surveys of the paintings were conducted; using archive sources including old photographs and engravings, they were re-collocated in their original position in the new 3D model corresponding to the 19th century phase. The creation of 3D models specific to the individual historic phases of the church gives rise to the concept of '3D digital restoration', understood not as an approach to the ideal reconstruction of an architectural item, but as a method for the verification and the re-composition of analytical data, aimed at the study of the functional and structural logic of a building by means of innovative methods of visualisation.

Figure 10: S. Maria di Cerrate, frescoes on South wall: a. actual state, b. virtual restoration, c. virtual reconstruction

2.5 The rupestrian church of Madonna delle Croci: laser scanning survey

Entrance to the crypt is through a round arch with a simple rectangular door in the centre of a semicircular façade carved in the rock which contains a series of niches and engraved crosses. The interior, rectangular in shape and oriented East-West, is subdivided into two vaults separated by a segmental diaphragm arch. Each vault is supported at the sides by blind arches where, in the vault closest to the entrance, numerous crosses are engraved. The name of the crypt derives from the presence of crosses engraved on the walls and three large crosses on the vaulted ceilings. In the vault closest to the entrance are two crosses in relief, both set in the centre of a circular cavity, the first of which is of the "pattée" type and the second of the "potent" type. In the inner section of the church, the ceiling is of the groin vault type, and between the arrises on the side of the apse is a third large cross inscribed in a circle, also of the "potent" type.

Of the original pictorial decoration, only the fresco on the apsidal vault remains. Dated to between the 12th and 13th centuries, the fresco reflects the typical Byzantine-style iconography of the enthroned Madonna and child flanked by two archangels, Gabriele and Raphael.

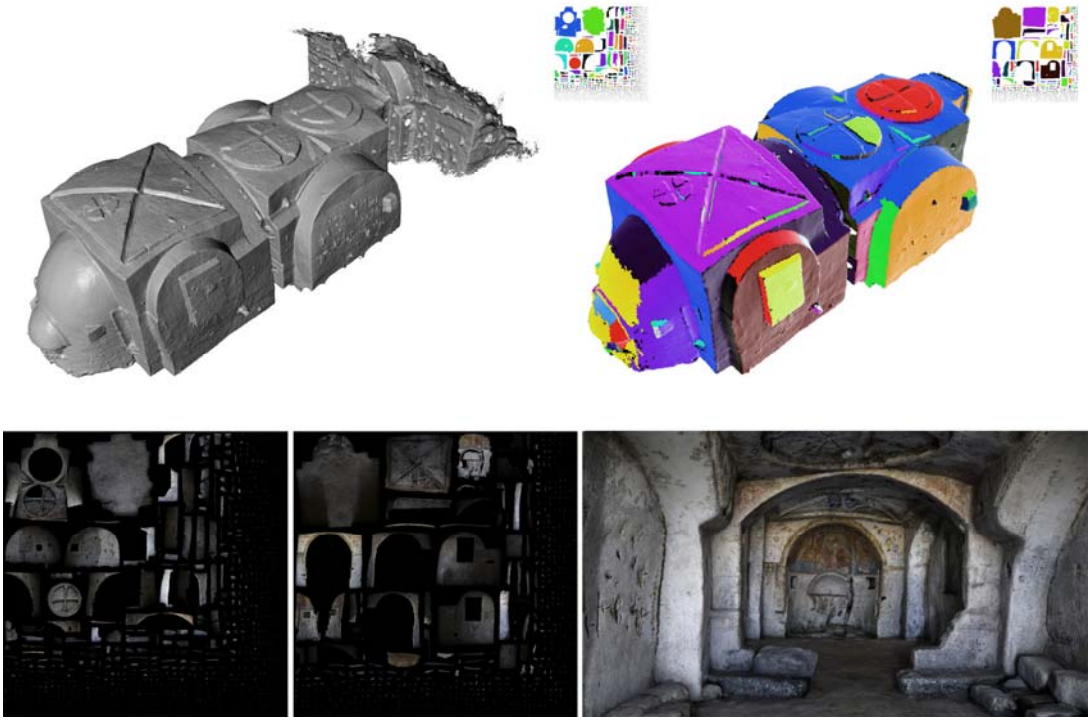

Figure11: Madonna delle Croci, Matera. The four phases of 3D restitution with laser scanning technique: 1. The shading view of 3D model without texture; 2. camera mapping patches; 3. UVW texture associated with the camera mapping method; 4. The final 3D model with image based lighting.

The survey of the internal walls of the crypt was performed with an time of flight laser scanner. The acquisition was based on domes of about six metres in radius, with a level of detail of the point clouds of 4 mm. Five scans were necessary, three inside and two outside, to describe the entire item with a good coverage of the undercuts. The scanner proved to be fast and reliable, but the editing of the point clouds required a considerable effort on the part of the operator to resolve problems caused by exporting in the dxf format, which resulted in pronounced anomalies and discontinuities in horizontal bands at regular intervals. In each case the manipulation of the meshes using software dedicated to the management of point clouds resolved the problem satisfactorily, and the results are visible in the images shown in this article. The polygonal mesh was subsequently decimated in order to maintain the number of polygons within a limit that was empirically tested on normal consumer computers, in the order of 400-500 thousand polygons. In the texturing phase, this limit, imposed for reasons linked to the performance of the Realtime engine, considerably simplified the selection of the groups of faces to which each individual material was assigned. The internal walls were mapped using the *Camera Mapping* method, well-known and used in cinematography, but rarely used in other applications such as the restitution of monuments. This method allows to project a texture on 3D model using the same coordinates of the photo: this will minimize the distortions induced by other mapping methods and achieving a perfect overlap between model and texture.

Our experience has shown the excellent performance of CM on curved surfaces, for example the apsidal wall or the underside of the arches of the lateral walls; on all the other surfaces an extensively subdivided planar projection was used, again to limit distortions in the undercuts as much as possible.

Figure 12: Madonna delle Croci, Matera. 3D realistic view.

The hyper-realistic result clearly derives from the skilled fusion of the individual polygonal 'sectors' mapped using these techniques, but another element that contributes to the photorealism is the choice of illumination, which must be as close as possible to the natural illumination resulting from the original photographs, obtained using a 12 Megapixel camera in RAW format. The choice of illumination was based on the Radiosity-type algorithm, using HDRI (High Dynamic Range Image) images and area light from the church's only opening. The artificial light merely helped to accentuate the atmosphere of a closed and dark space, stressing the light-dark contrasts, also accentuated by the closed nature of the environment. The final model of the entire complex is made up of about 300,000 polygons with two textures re-sampled at 7000x7000 pixels. The Realtime navigation is easily managed on a normal consumer PC, with non-professional hardware and software configurations. The level of verisimilitude can be judged from the images shown here.

3. The Iraq Virtual Museum experience

3.1 General issues

The experience that is presented here was gained in the context of the Virtual Museum of Iraq project promoted in 2006 by the Italian Ministry of Foreign Affairs and carried out by the Italian National Research Council (CNR). The project is designed to create contents based on the archaeological collection of the one of the most important museums in the world. The creation of an innovative virtual museum shows the need to explore new digital communication systems to access into an impressive archaeological collection, currently not available yet. Most important civilizations of the ancient Mesopotamia, from the emergence of the Neolithic villages (7000 BC) until the Islamic Period (IX-X century AD), are perceived in a long-time historical sequence. The virtual tour is carried out across eight virtual exhibitions organized according a chronological sequence. The "Virtual Museum of Iraq" Project is not the real museum of Baghdad transposed to the web or to any electronic form. Moreover, the ordinary visitor not perceives the virtual collection of artefacts as an archive of database, the virtual platform could be claimed as the communicative projection of the real museum.

Figure 13: The Assyrian Room of Iraq Virtual Museum. 3D models obtained with image-based technologies.

3.2 Problems of documentation and communication in a virtual environment

The experience developed during the Virtual Museum of Iraq Project allowed to highlight some fundamental questions, which it was need answer concretely: whom and what have we to communicate? Which contents can we communicate? Which kind of techniques can we use? And, above all, which are the expected results?

The content and the target audience of a communication project are inextricably linked. Very often in multidisciplinary research conducted by heterogeneous teams which include figures from both the humanities and technical-scientific disciplines, there is a tendency to combine mixed content in a single end-user environment; thus, historical data are accompanied by the results of chemical tests, and artistic analyses by technical data on a monument's stability. In contrast, in the Iraq Virtual Museum project every single methodological choice is based exclusively on historical data. Every technical solution adopted for the reconstruction of the Iraqi monuments and the individual rooms of the museum is guided by this one objective: to present, concisely but thoroughly, the history of the land between the two rivers via video clips, records and images that may be understood by all users.

Figure 14: The Acheamenid and Seleucid Room. 3D models obtained with image-based technologies.

As often happens when dealing with human creativity, the process of simplifying the message and the content to be transmitted can become extremely difficult to manage. Less is more, proclaimed the masters of modern architecture, with the risk however of saying too little, perhaps of being superficial, while the opposite approach tends to redundancy, potentially

boring the visitors with content that is too elaborate or specialised. The result of these reflections is the identification of three fundamental elements for learning: the first is the architecture of the museum room itself. The concept of a room in a museum is associated with the broader notion of cultural and historic identity: the setting up of virtual rooms has made it possible to gather significant pieces from the period of reference, enabling the visitor to immediately recognise the tangible signs of a particular way of life and thus to delineate the features that establish the distinctive character of the period. This approach recreates in the virtual environment the familiar procedure of visiting a real museum, helping the visitor to understand the value of the exhibit as testimony, which is the second and perhaps the most important element in the process of creating the museum. The exhibit links form and content indissolubly, and establishes a clear image of the historic period, facilitating the development of those cognitive processes that are stimulated by visual memory, highly effective in most visitors. In this sense, the use of technology for three-dimensional representation of the exhibits becomes a means of increasing their appeal even further, since a model that can be explored interactively is undoubtedly more striking than a simple image.

Figure 15: Iraq Virtual Museum, 3D reconstruction of Shalmaneser III throne

The 3D modelling of the exhibits was performed to a large extent with rotoscoping techniques, using images that had already been published or were available on the web; only in a few cases was it possible to use high quality images. Nevertheless, many 3D exhibits on display in the virtual museum are also valuable as documentation, because thanks to image-based restitution techniques they make it possible to study details and take measurements. Emblematic in this regard is the reconstructive study and photo-modelling of the helmet of Meskalamdug, which may be explored on the project's website in RealTime3D.

The third element, extremely important from the museographical point of view, is the contextualisation of the exhibits in their context of provenance. Very often in traditional museums, groups of exhibits of the same type are displayed in accordance with purely aesthetic criteria, neglecting their function or symbolic significance in order to highlight individual stylistic aspects. However, there are sculptures such as the Assyrian Lamassu or the orthostats of Khorsabad, which would be practically incomprehensible if removed from their specific architectural contexts. This led to the idea of describing the complexity of these situations by means of animated video clips, in which the exhibit is reconstructed together with its context of provenance, regional surroundings and city environment. In this broader vision, the process of communication and setting up the virtual museum tend to coincide, because the video clip does not describe the museum but is an integral part of it. It reveals and deciphers, rapidly and concisely, the content of the item, placing it in the historic period to which it belongs.

In this context the expected result is to provide the visitor with the key to understanding historic phenomena and the tangible signs of material culture, as displayed in eight rooms corresponding to eight historic periods. The interactive vision of the exhibits includes their territories of origin, studied in detail. The basis for this is a narrative of great emotional impact, using the language of 3D Computer Graphics.

4. The reconstruction of ancient landscape

4.1 The reconstructive studies of Rocca Montis Dragonis between technicism and realism

The system of the Petrino Mountain, on which the medieval fortress is situated and of the ancient street Appia constitutes a sort of container of the human history thanks to the presence of numerous archaeological sites dated from the prehistory to the Renaissance and

modern age. The topographical investigations conducted in the last years in this area have produced a big repository of all the archaeological sites, and so it is possible to reconstruct, through the landscape archaeology, the settlement systems in the various historical (from the prehistory to the modern age) periods and the approach of the communities to the various available resources. In such sense the medieval village of Rocca Montis Dragonis with its castle is becoming a point of reference, to European level, to rewrite the history of the medieval settlement and the history of the specialized agricultural crops among which the grapevine and the wine. The archaeological research is now focusing the attention to such rich territorial resource, reflected by the interest of a large number of scholars, administrators and local bodies. They are now trying to promote actions aimed to repeat, in this area as in others regions of Italy and Europe, the experience of many archaeological and environmental parks, and of history of the agricultural resources parks, that are conjugating with success the exploitation of the local resources and the safeguard of the environmental and archaeological goods.

For this study we have created some tools of communication that are easy to understand and can be used to develop narratives (storytelling) that describe, using the methods of Virtual Reality, the results of archaeological explorations undertaken in recent years, highlighting the distinctive aspects that gave rise to and shaped the medieval phenomenon of "incastellamento". The methods used in this study are based on specific observations, traces of material culture and the detailed analysis of settlement patterns, with a view to making general interpretative observations concerning the architecture of the Rocca Montis Dragonis fortress, together with social and economic factors that influenced its construction. The aspect of greatest technological interest in this project concerns the possibility of managing the reconstruction of the architectural complex together with the original arboreal ecosystem. Given that the entire hill on which the settlement stands is covered in thousands of 3D instances, this is highly challenging in terms of managing individual polygonal objects. The management of the mass of trees was entrusted to specific software (Vue d'Esprit Xtreme, in this case) which enabled us to manage more than 150 million polygons, rendered with a radiosity algorithm and ambient occlusion, which are known to confer a realistic appearance on the entire reconstruction. The three-dimensional representation of the hill and a large portion of land around it was achieved by interpolation of the contours on a scale of 1:2000. In general terms, the three-dimensional rendering was also convincing in the close-up views. In the views presented here it is possible to assess the final result of this operation, with the

ancient complex processed in a range of light and environmental conditions. Obviously, the atmospheric effects are also the result of three-dimensional volumetric simulations: clouds and sun are in continuous movement, not only to enable different readings of the monument at various hours of the day, but above all to heighten the sense of wonder, in a vision that seeks to narrate and represent the past.

Figure 16: Virtual reconstruction of Rocca Montis Dragonis. The complete medieval fortress

This approach to ultra-realistic rendering is part of a tendency over the last few years, which have seen considerable progress and growth in the technologies used for the study and visualisation of ancient contexts. The specific solutions produced by software companies, in terms of both realism and Real Time 3D applications, are being taken up by increasing numbers of archaeologists and historians. The use of Virtual Reality enables them to give their research and products a more interesting appearance and to provide non-expert users with communication tools that can have great emotional impact. This approach is not just about seeking the most technologically advanced solution, but it is in line with current developments in entertainment and Cultural Heritage communications. Indeed, we are convinced that the effectiveness of Cultural Heritage communications depends to a large extent on freeing representation from the sterile VR interfaces of the 1990s. At that time a narrow technicism was vaunted as evidence of having reached high scientific standards, with results that were defined historically as “cold” – “synthetic images” that were characterised by their typically computer-generated appearance. The conviction that Virtual Archaeology

has no need of extreme realism still persists in some research environments and is often accompanied by reconstructions may be regarded as merely typological or general in character. All this in the age of unbiased rendering engines, ultra-realistic Real Time simulators and CG productions that may truly be said to constitute new forms of visual art. Today representation has to aim at realism and the emotional involvement of the spectator, using the same techniques as modern cinematography. In the project presented here, the realism comes in the simple form of a video, which however has great value from both the emotional impact and the scientific point of view, making use of laser scanning, camera mapping, particle effects, new rendering engines, image-based modelling and other highly advanced modelling techniques. Communication in this case becomes "spectacular" and a vehicle for high-level content, suitable for all levels of user, but created with tools of great scientific value, founded on interdisciplinary research and dialogue between different forms of knowledge.

Figure 17: Rocca Montis Dragonis, views of the surrounding area

5. Conclusions

The reconstructive study of a monument today can make productive use of 3D technologies and advanced visualisation systems, achieving results that were unimaginable just a few years ago. Studying a monument in every detail, visualising forms and colours in three dimensions,

is now an indispensable support for researchers. Thanks to technology the case studies proposed here makes it possible to open a window on our past, hopefully it will also help to soften the diffidence that is sometimes shown towards 3D technologies, which are frequently abused in reconstructive proposals. Anyway the true objective is and remains historical and archaeological research, which thanks to Virtual Reality can be narrated and represented as never before.

The signals for the future encourage the use of virtual technologies in the edutainment world: even though the high technological level and the greater power of communication implicit in the interactive Realtime 3D systems already described, the public now seems more interested in passive systems like the 3D movie or animated virtual presentation, probably for the greater communication impact. In our work, both solutions are anyway characterized by a high level of realism.

The purpose of this type of works remains essentially communicative and museum-oriented; its represents an extremely effective way of surveying the current state of an item and of enabling distance viewing of both accessible and inaccessible sites, thanks to them the user can not only learn but also be encouraged to pay a visit in situ. This can only facilitate the non-virtual (but highly important) process of capitalisation of Cultural Heritage.

Figure 18: Screen-shot of Virtual Abriola, Realtime 3D platform for the distance visiting of the Basilicata territory.

Figure 19: 3D restitution of the *Ara Pacis Augustae*, using only image-based techniques

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