

## OTRANTO TREASURES IN 3D

*Virginia Valzano\*, Fabio Negro\*\*, Domenico Lucarella\*\*\**

\*University of Salento – CEIT, Italy

\*\*Leaf Software s.n.c. - Maglie (LE), Italy

\*\*\*University of Salento, Italy

### Abstract

Otranto is an Italian city located on the Adriatic coast of the Salento peninsula, on the easternmost stretch of Italy. Always considered one of the pearls of the Mediterranean, Otranto exudes a timeless charm, with its countless historical, artistic and naturalistic beauties. "Otranto Treasures in 3D" is a video-documentary that tells the millennial charm of Otranto's, landscape, culture and nature through video footage and 3D reconstructions. The video allows a guided virtual tour of the wonders of Otranto, to discover this ancient town, to know and admire its churches and its splendid monuments and some ancient settlements and archaeological sites of remarkable relevance, such as the Grotta dei Cervi in Porto Badisco, and to dive into a crystal blue sea, a realm of enchanting habitats rich in biodiversity and spectacular backdrops.

### Keywords

Otranto, Porto Badisco, 3D movie, CoCoNet, Mediterranean in 3D, Underwater 3D filming, Grotta dei Cervi, Deer Cave, Aragonese Castle, Castel's Chapel, Donna Teresa de Azevedo, Three-dimensional reconstruction, Virtual representation, 3D models, 3D imaging, 3D animation, Texture mapping, Cultural Heritage

### 1. Introduction

Otranto is an Italian city of over 5.900 inhabitants in the province of Lecce, in Puglia (Italy). It is located on the Adriatic coast of the Salento peninsula, on the easternmost stretch of Italy, on a rocky outcrop overlooking the sea. The Cape of the same name, also called Punta Palascia, south of the inhabited centre, is the easternmost geographical point of the Italian peninsula, where one can admire the first dawn of the new year breaking over Italy, and lose oneself among the wonders and flavours of an enchanting and suggestive landscape, dominated by a picturesque vegetation and a blue and crystal-clear sea, realm of beguiling habitats, rich in biodiversity and spectacular sea beds.

Always regarded as one of the pearls of the Mediterranean, Otranto exudes a charm out of time, with its countless historical, artistic and naturalistic beauties.

At first Greek-Messapian and Roman centre, then Byzantine and later Aragonese, the city of Otranto develops around the imposing Castle and the Norman Cathedral. Archbishop's seat and important tourist center, it gave its name to the Canale d'Otranto, which separates Italy from

Albania, and the Terra d'Otranto, an ancient district of the Kingdom of Naples. In 2010 the ancient village was recognized as a UNESCO Cultural Heritage Site as a Messenger of Peace. It is part of the Club "The most beautiful villages in Italy".

### 2. Otranto Treasures in 3D

"Otranto Treasures in 3D" is a documentary video on the lovely, millenary landscape and culture of Otranto, presented through video shooting and 3D reconstructions.

The video allows a guided virtual tour of the wonders of Otranto, to discover its ancient town, to know and admire its churches and its splendid monuments and some ancient settlements and archaeological sites of remarkable relevance.

The video-documentary has been realized with mixed techniques of 3D visualization and video shooting. It is intended for a wide audience of scholars and tourists, and is accessible on DVDs and the Net, in Italian and English.

It allows a journey through time of the Otranto area, accompanied by an original and fascinating background music.

Both video shooting and three-dimensional reconstructions allow users to know and enjoy, even at a distance, some fascinating and suggestive treasures of Otranto: to immerse themselves in a crystal clear blue sea, kingdom of enchanting habitats rich in biodiversity and spectacular depths, and to penetrate and admire, some environments and archaeological sites still wrapped in an aura of mystery and legend, such as the Grotta dei Cervi in Porto Badisco and the Chapel of the Castle of Otranto.

The three-dimensional reconstructions are also accessible in stereoscopy, in real time and interactively, through the 3D Virtual Theater of CEIT-Euromediterranean Center for Technological Innovation for Cultural and Environmental Heritage and Biomedicine (<http://www.ceit-ottranto.it/>).

The multimedia product was designed and realized by Virginia Valzano (founder and director of CEIT), with the cooperation of the Department of Mathematics and Physics of the University of Salento (founding partner of CEIT) and various professional skills.

### 3. Underwater 3D Filming and CoCoNet project

The underwater 3D filming contained in the video has been made available by prof. Ferdinando Boero, coordinator of the European CoCoNet Project, for the protection of marine environments, and was created by Roberto Rinaldi, underwater photographer and cameraman in all the seas of the world, also on board of the Calypso led by Jacques Cousteau (Fig. 1).

CoCoNet (Towards COast to COast NETWORKS of marine protected areas, coupled with sea-based wind energy potential) is a project of the EU Oceans of Tomorrow programme.

CoCoNet tackled two problems that are closely linked with each other: the protection of the marine environment and clean energy production. Hence, the Supplement is divided into two parts that, together, form a unicum. The first one is the Guidelines to design networks of Marine Protected Areas in the Mediterranean and the Black Seas, the second one proposes the principles to install Offshore Wind Farms in both basins, based on a Smart Wind Chart that couples environmental and economic sustainability. The CoCoNet Consortium involved scientists from 22 states, based in Africa, Asia, and Europe, contributing to build a coherent scientific

community. The availability of the results of CoCoNet as a single product in an Open Access platform will hopefully guarantee the spread of the knowledge that the CoCoNet Consortium generated, hoping that it will contribute to a wiser use of the natural capital and to the growth of human welfare (Boero, Valzano, & Bartolomei, 2016).

The results of CoCoNet project have been published in the Supplement of volume 6 (2016) of SCIRES-IT (Boero, Foglini, Frascchetti, Goriup, Macpherson, Planes, Soukissian, & CoCoNet Consortium, 2016).

The underwater 3D filming was made using an innovative high definition three-dimensional shooting system, designed by Roberto Rinaldi himself.



**Fig. 1:** Underwater 3D Filming

Roberto Rinaldi has been an underwater photographer and cameraman since the early 80's. He spent many years working aboard Jacques Yves Cousteau's Calypso. His movies were aired on major television channels around the world.

In 2009, he invented a new concept for filming in 3D underwater. The system was built by the Austrian company SEACAM. It is the only underwater 3D system in the world, compact, small, handy, capable of operating underwater up to 150 meters deep (Rinaldi, 2014).

A detailed description of this system has been published in the issue n. 2 vol. 4 (2014) of e-Journal SCIRES-IT.

The 3D underwater shootings are also accessible in stereoscopy through the 3D Virtual Theater of CEIT.

### 4. Ancient origins of Otranto

Because of its geographical position Otranto was regarded since antiquity as a natural bridge between Orient and Occident; it still retains

evidence of the encounter between different cultures.

In the video Otranto, with its thousand-year-old charm, tells its history through its ancient city centre, its churches and its monuments; among these are the imposing Aragonese Castle, the church of San Pietro, a precious evidence of the Byzantine rule in Terra d'Otranto (Fig. 2), and the Romanic Cathedral (Santa Maria Annunziata), with its façade decorated by a magnificent rose window with 16 spokes and its interior displaying a precious mosaic pavement by the monk Pantaleone, representing the Tree of Life, with scenes suspended between the sacred and the profane (Fig. 3).



Fig. 2: Church of San Pietro

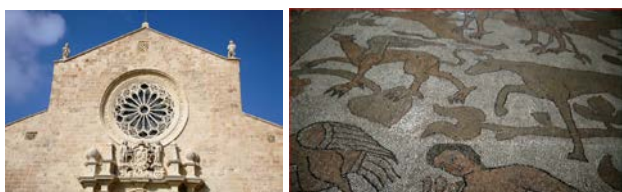


Fig. 3: Cathedral; mosaic pavement.

Next to the residential area one can admire the hypogaeum of Torre Pinta, a rare example of dovecote tower of medieval times, built upon a previous structure (Fig. 4).



Fig. 4: Torre Pinta hypogaeum

Along the coast, the chain of watchtowers built by the Spanish viceroys, can strike one with wonder and astonishment, whereas inland there

remain the mute and silent remnants of the monastic complex of S. Nicola di Casole (Fig. 5). Within the abbey, a library and a scriptorium were conspicuous before the devastating fire set by the Turks.



Fig. 5: Monastic complex of San Nicola di Casole

Otranto, however, has far more ancient origins that are lost in legend. A legend that is intertwined with history.

Along the Otranto coastline, in the rocky cove of Porto Badisco, deep in the earth lies the Grotta dei Cervi (Deer Cave), which was used as a natural shelter and a sanctuary from the Upper Paleolithic to the Metal Ages.

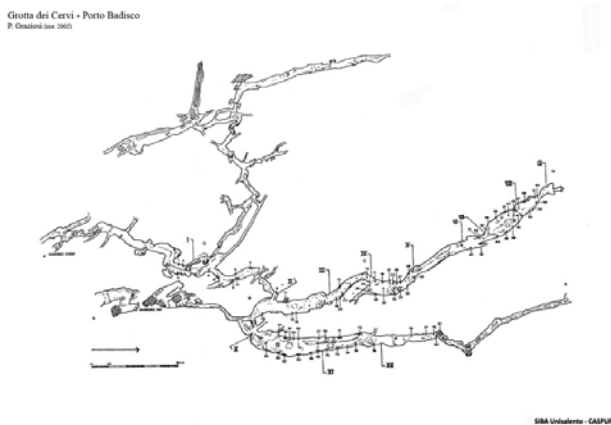
##### 5. The "Grotta dei Cervi" in Porto Badisco

The "Grotta dei Cervi" (Deer Cave), discovered in 1970 by a team of local speleologists<sup>1</sup>, is located in South-eastern Italy at Porto Badisco (40°04'47"N, 18°29'02"E), Otranto (LE, Italy). The main entrance is situated at 26 m above sea level and the largest depth is about 26 m. The temperature is fairly constant at 18°C and the RH hovers between 98% and 100%.

The Cave is one of the most significant archaeological sites of the Salento region due to the presence of an extraordinary repertoire of Neolithic pictographs as well as the evidence of prehistoric human dwelling over a long period of time.

The site extends for more than 1,500 m., along three main corridors whose walls are decorated with pictograms done with red ochre and, in greater number, with a mixture of ochre and bat guano (Fig. 6).

<sup>1</sup> The Cave was discovered by a team of speleologists of the Salento Speleological Group "Pasquale de Laurentiis" from Maglie (Lecce, IT): Severino Albertini, Enzo Evangelisti, Isidoro Mattioli, Remo Mazzotta, Daniele Rizzo. Collaborators: Nunzio Pacella, Pino Salamina.



**Fig. 6:** Map of the the “Grotta dei Cervi” (P. Graziosi, 2002)

The paintings depict hunters, animals, magical symbols, abstract geometries, and deer hunting scenes, after which the Cave is named <sup>2</sup> (Fig. 7). It was defined the “Sistine Chapel of Prehistory” by the Italian archaeologist and anthropologist Paolo Graziosi (Graziosi, 2002).



**Fig. 7:** Grotta dei Cervi, Neolithic cave. Photographs showing pictographs (Guano, Okra), petroglyphs and speleothems. (in the photos: V. Valzano, J.-A. Beraldin; N. Ciccacese, V. Valzano)

A unique place of worship in Europe, the Grotta dei Cervi cannot be easily accessed and is closed not only to the general public, but also to researchers, so as not to alter the delicate micro climate which has so far allowed the conservation of the painting (Fig. 8).



**Fig. 8:** Grotta dei Cervi (Deer Cave)

Its visualization has been made possible to a wide public thanks to the Project “Grotta dei Cervi – Porto Badisco”, a “Project of three-dimensional acquisition and reconstruction, and virtual representation” by Virginia Valzano, carried out in the years 2004-2010, within the Piano Coordinato of the Universities of Catania and Lecce, co-financed by the European Union (FESR, PON Ricerca 2000-06) and coordinated by Mauro Biliotti, University of Salento (<http://www.ceit-otranto.it/index.php/progetti/24-grotta-dei-cervi-porto-badisco>).

The project was started in 2003-2004, coordinated by Virginia Valzano, Director of “Coordinamento SIBA” of the University of Salento<sup>3</sup> (see: <http://www.ceit-otranto.it/images/valzano/siba-1986-2010.pdf>), and was carried out in agreement with the Archaeological Superintendence of Puglia (at the time directed by Giuseppe Andreassi), with the collaboration of some Structures of the University of Salento, a team of Canadian NRC (National Research Council Canada) and the CASPUR (Interuniversity Consortium for Supercomputing

<sup>2</sup> One of the most famous pictograms is the so-called “Dancing God”, which depicts a dancing sorcerer, and has become somehow the symbol of Salento, Italy (see: Fig. 8).

<sup>3</sup>“Coordinamento SIBA” (Servizi Informatici Bibliotecari di Ateneo), started by Virginia Valzano and directed by her from 1986 to 2010, coordinates the Library Computer Services and the Telematic Information System for Research and Education at the University of Salento.

for University and Research) of Rome<sup>4</sup>, at the time directed by Francesco Proietti.

A reconnaissance visit to the grotto in February 2004 allowed the team to plan the activities.

The 2D and 3D digital acquisition of wall paintings and hypogeum environments, hard to access and with a high humidity rate, was extremely complex and required highly specialized skills and high-tech equipment suitable for use in extreme environmental conditions (Fig. 9).



**Fig. 9:** High-tech equipment suitable for use in extreme environmental conditions and Team member at work. (in the photo: V. Valzano)

Two laser scanners were used in order to acquire the inside walls and some of the external structures.

The first scanner used in 2005 (Fig. 10) was a prototype triangulation-based multi-resolution 3D laser imaging scanner (developed at NRC and known as “Big Scan”) that made it possible to acquire the shape information of the three main chambers (important pictograms) with a spatial resolution that improved with shorter standoffs (Beraldin, Blais, Cournoyer, Picard, Gamache, Valzano, Bandiera, & Gorgoglione, 2006).

<sup>4</sup> CASPUR (Consorzio interuniversitario per le Applicazioni di Supercalcolo Per Università e Ricerca) is an Interuniversity Consortium for Supercomputing for University and Research founded in Roma (Italy) in 1992 by four Universities of south-central Italy (la Sapienza University in Rome, the Polytechnic and the University of Bari, the University of Lecce). Over the years, seven other Universities of south-central Italy joined CASPUR. After twenty years of activity aimed at the “exploitation of research for society: scientific computing and technological innovation”, CASPUR flows in CINECA, and in 2013 becomes “CINECA – Operational center of Rome”. The process of merging the consortia CASPUR and CILEA in CINECA was started in 2012 on the initiative of the Ministry for Education University and Research (MIUR) with the goal of having a single legal entity and to equip the national academic system and the search for a technology partner with which to strengthen the international competitiveness of Italy in the field of research and education by improving the efficiency and synergy between organizations and institutions.

The second scanner used in 2009 (Fig. 11-12) was a commercially-available system, a time-of-flight 3D laser scanner, that recorded 3D data at a range from 0.5 m to 19 m. (Beraldin, Picard, Valzano, Bandiera, & Negro, 2011).



**Fig. 10:** Multi-resolution 3D model of a section of the cave with a series of pictograms - photograph of close range scanner, (3D laser scanner 2005).



**Fig. 11:** A section of the cave with pictograms, and scanner at work (3D laser scanner 2009)



**Fig. 12:** A section of the cave with pictograms. Team member and scanner at work (3D laser scanner 2009)

Two sets of high resolution and detailed three-dimensional (3D) acquisitions were captured in 2005 and 2009 respectively, along with two-dimensional (2D) images.

Carbon dating of the guano used for the pictographs and environmental monitoring (Temperature, Relative humidity, and Radon) completed the project.

The work has been documented with the support of video information.

Four teams worked on the project during the two campaigns (2005, 2009): a two-person team for the acquisition of the 3D data, a four-person team for the digital photography, a two-person team for safety, and a two-person team located above the cave in a camper. The last team was responsible for coordinating all communications amongst team members and for pre-processing of data. A LAN assured an uninterrupted video/audio link and data backups. Two separate electrical cables connected to a low noise gas-powered generator provided electricity to the 3D and photography teams respectively (Beraldin, Picard, Valzano, Bandiera, & Negro, 2011). Two experienced speleologists and two archaeologists joined the team and took an active role during the recording.

The 10-day long visit into the Grotto, in February 2005, generated more than 100 GB of 2D and 3D data that required the development of new tools for modelling and managing the archive.

A total of 35 GBytes for 716-3D images with photographs and 65 GBytes for 1786-high-resolution colour texture photographs were acquired.

The 15-day long visit into the Grotto, in May 2009, generated 82-3D spherical images for a total of 26.4 Giga 3D points (106.7 GBytes of raw binary data) and 2481 2D images for a total of 35.5 GBytes of texture.

From this information a textured 3D model was produced for most of the 300-m long central corridor (Fig 13, 14, 15).

This corridor has passage ways barely allowing an adult in and some chambers have a maximum cross section of about 8 m wide × 5 m high (see Fig. 9).

The main concerns were the technical difficulties the team might encounter and the determination of the required spatial resolutions. We had strict guidelines to follow before entering the Grotto (Beraldin et al., 2006).

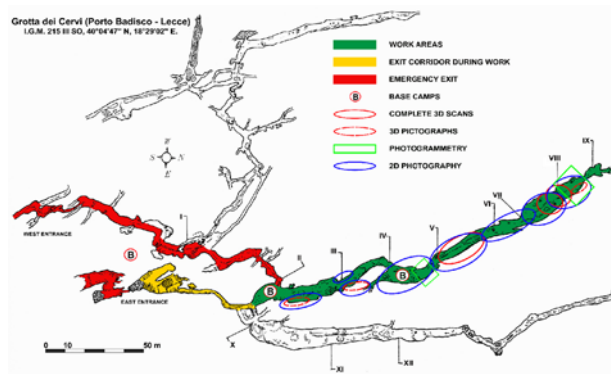


Fig. 13: Map of the cave and illustration of the areas completed



Fig. 14: A section of the Grotto dei Cervi, Neolithic cave. (in the photo: N. Ciccarese)



Fig. 15: A section of the Grotto dei Cervi, Neolithic cave. (in the photo: F. Negro)

Moreover, the biggest problem was related to the size and resolution of 3D images which caused computer crashes and excessive processing time: the hardware and software tools on the market 10-15 years ago did not allow to process and display high quantities of data. Due to the sheer quantity of data generated by the 2D and 3D acquisition campaigns, the

development of new tools for modeling and managing very large textured polygonal meshes was necessary.

The “Grotta dei Cervi – Porto Badisco is a pioneering project that, 10-15 years ago, pushed 3D technology to higher levels.

The large amount of high-resolution 2D and 3D image data has opened the door to providing a 3D model of the caves of unmatched resolution, never obtained before in any 3D model of a grotto site.

In the years 2005-2010 this was a major scientific milestone in modelling large and complex 3D environments.

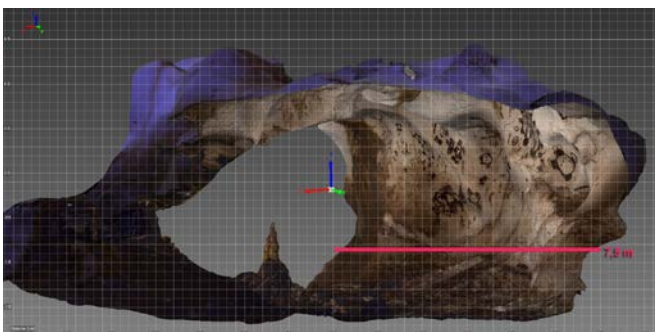
The 3D textured model allows for a virtual access to the site and pictographs without invading the fragile environment of the Cave (Fig. 16).

High-resolution textured 3D models of the cave contain a wealth of information that can be examined and analyzed for a variety of conservation, research, and display applications.



**Fig. 16:** 3D model of a cave wall (m 5.70 x 2.65)

Some parts of the Cave can be accessed in stereoscopy, in real time, in immersive and interactive way, through the 3D Virtual Reality Theatre of CEIT (Fig. 17-18).



**Fig. 17:** Three-dimensional reconstruction of a section of the Grotto (Zone V)



**Fig. 18:** 3D animation of zone V

The high-resolution 2D and 3D data acquisitions could allow a full-scale, physical and faithful reproduction of the most representative areas of the cave, as it was done for the Lascaux Cave.

A detailed description of this Project, on the results obtained and the best practices emerged from this work, has been presented and published in various Conferences and Proceedings (see References), in particular in the Conference held in Otranto in 2010 and in the paper “Best Practices for the 3D Documentation of the Grotta dei Cervi of Porto Badisco, Italy”, by Beraldin, Picard, Valzano, Bandiera, and Negro (2011).

The “Neolithic Mysteries: Revealing in 3D the Grotta dei Cervi of Porto Badisco” DVD (2009-2011), edited by Virginia Valzano, contains the backstage and the results of the work of acquisition and three-dimensional reconstruction, scientific articles and other documentation presented at the 2010 Conference in Otranto.

An excerpt from the video was ranked first nationally in the “eScience and Technology” section of the Italian eContent Award 2009 and nominated for the World Summit Award 2011. It was awarded for the best content in digital format, for scientific rigour, methodology and innovative technological applications.

#### 6. *The Aragonese Castle and the Chapel of Donna Teresa de Azevedo*

A Messapian settlement, attracted to the sphere of influence of Rome and later of Byzantium, Otranto suffered the Aragonese domination, which inexorably, for defensive reasons, changed its outlook.

In an air of mystery, the ancient city centre survives almost untouched, with its winding alleys, paved with bare stone, which meander like labyrinths surrounded by white houses.

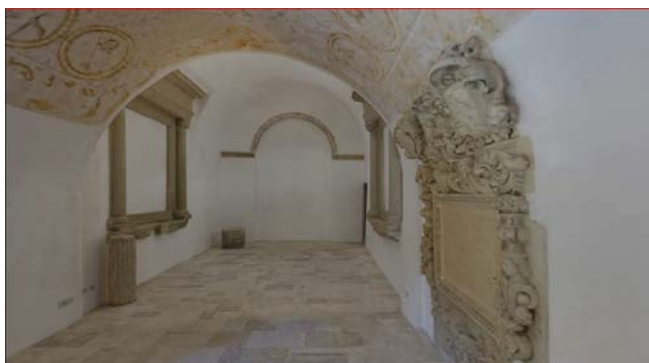






**Fig. 23:** Rendering of 3D Model Textured, a detail of the vault

In particular, the three-dimensional reconstruction of the Chapel is accessible through the 3D Virtual Reality Theatre of CEIT in stereoscopy, in real time and in an interactive way (Fig. 24).



**Fig. 24:** 3D Animation. The Castel's Chapel (Chapel of donna Teresa de Azevedo)



**Fig. 25:** Donna Teresa de Azevedo's sepulchral monument

The methodology and technology used for this project can be easily replicated for the three-dimensional reconstruction and virtual

representation of environments and architectural structures for which interventions are planned both for study and restoration and in order to spread their knowledge for cultural and tourist purposes (Valzano, Negro, & Foschi, 2017).

The small church, built in early XVI century, is made up of a rectangular room with a barrel vault ceiling. On the ceiling there are sinopias and frescoes depicting a tondo with the Coronation of the Virgin in the middle, and a sequence of medallions with sacred figures along the lower part of the vault (Fig. 23).

Inside, Donna Teresa de Azevedo's eighteenth-century sepulchral monument made of typical Lecce stone stands out, harmoniously decorated with Baroque motifs and beholding a tender epitaph (Fig. 25).

The monument was built in her memory by her husband, don Francisco de la Serna y Molina, to preserve the sweetness of their old love.

Tender and intense the words carved by her consort for his loved one as a seal of their eternal love. The epitaph tells us who donna Teresa, who died at a young age, was: descendant of a noble Spanish family, beautiful like a goddess, an example and epitome of modesty and honesty, she was suddenly abducted by death the seventh day of the calends of March, leaving her husband, at the time royal prefect at Otranto, in despair.

In this out-of-time place, by looking up, one can get a glimpse of the traces of the ancient walled grating from where the nobles could attend religious services without mingling with the soldiers. On the wall of the upper floor one can admire a fresco depicting an aristocrat.

According to the legend, the nobleman was melancholic Don Francesco. He would have his effigy imprinted there so that he could watch eternally over his beloved wife and the underlying chapel, where their love continues to vibrate still today (Fig. 26).



**Fig. 26:** Traces of the ancient walled lattice; the nobleman Don Francesco (don Francisco de la Serna y Molina)

A sweet story of endless love, which has resisted time and still excites, even more in a

moment of great reflection on gender violence, a very serious social problem that knows no geographical or cultural boundary.

### 7. *The background music*

The video-documentary allows a journey through time in the Otranto area; it is accompanied by an original and fascinating background music.

The original music, which accompanies the virtual visit among the treasures of Otranto, was made by Daniele Durante, artistic director of the "Notte della Taranta" and founder, together with Rina Durante, of the Canzoniere Grecanico Salentino, which he brought all over the world the culture and popular music of Salento<sup>5</sup>.

The poem-song "Luna Otrantina", written by Rina Durante, Salento intellectual and writer, set to music by Daniele himself and sung by Francesca Della Monaca, also from Salento, echoes voices and memories, forms, signs and colors of a past that merges with the present, nostalgia and hopes, intense moments of awareness, of great dignity and cultural identity.

### 8. *Conclusion*

The video-documentary "Otranto Treasures in 3D - Tesori di Otranto in 3D", intended for a wide audience, was made with mixed techniques of 3D visualization and video shooting. It allows a virtual journey through time and in Otranto area accompanied by an original and fascinating background music, through video footage and 3D reconstructions.

---

<sup>5</sup>The Canzoniere Grecanico Salentino (CGS), founded in 1975 by the Salentine writer Rina Durante and by the musician Daniele Durante, is the most important group of Salentine folk music, the first to have been formed in Puglia. Since 2007, the GCS, under the direction of violinist and drummer Mauro Durante, succeeding his father Daniele, performs concerts all over the world reinterpreting in a modern way the traditions that revolve around the famous ritual tarantata pizzica, which had the power to heal through music, the trance and the dance, the bite of the legendary Taranta (tarantula). The CGS shows are an explosion of energy, passion, rhythm and magic, which drags you on a journey from the past to the present on the beat of the tambourine, the beating heart of the Salento tradition. Acclaimed by the public and critics, he has had numerous and important international awards and in 2018 he won the Songlines Music Awards which designates him as the best world music group in the world; is the first Italian folk group to win the Oscar for world music.

"Tesori di Otranto in 3D- Otranto Treasures in 3D" presents in a motion picture of excellent quality a bird's-eye view of what the Otranto area offers the visitor, from sea beds and other natural attractions to the many high-quality digital reconstructions of caves with pictograms and pre-historic graffiti and centuries old buildings. Not only does it promote and spread the knowledge of what may be seen in the area like a virtuous visiting card but also it collects and sews by an imaginary red thread some of the results of the most interesting historical investigations (Alfredo Ronchi, eContent Award Italy, 16 December 2015)<sup>6</sup>.

The video-documentary "Otranto Treasures in 3D" - "Tesori di Otranto in 3D" was ranked first nationally in the e-Culture & Tourism category of the Italian eContent Award 2015, and represented Italy at international level at the World Summit Award 2017.

The product was awarded the prize for the best cultural content in digital format, for scientific rigour, innovative methodology and technology applications. It is accessible online on the CEIT website, at the address <<http://www.ceit-ottranto.it/index.php/progetti/250-tesori-ottranto-3d>>.

---

<sup>6</sup>Alfredo Ronchi is a professor at the Department of Architecture, Built Environment and Construction Engineering of the Politecnico di Milano (Italy). He is the General Secretary of the European Commission-MEDICI Framework (Multimedia for Education and employment through Integrated Cultural Initiatives) and the Secretary of the European Working Group on "EU Directives and Cultural Heritage". He is the President of eContent Award Italy and member of the World Summit Award Grand Jury.

## REFERENCES

- Beraldin, J.-A., Blais, F., Cournoyer, L., Picard, M., Gamache, D., Valzano, V., Bandiera, A., & Gorgoglione, M. (2006). Multi-resolution digital 3D imaging system applied to the recording of grotto sites: the case of the Grotta dei Cervi. In *VAST'06 Proceedings of the 7th International conference on Virtual Reality, Archaeology and Intelligent Cultural Heritage* (pp. 45-52). Aire-la-Ville, Switzerland: Eurographics Association. Retrieved from [http://www.ceit-ottranto.it/images/documents/paper\\_cipa2006.pdf](http://www.ceit-ottranto.it/images/documents/paper_cipa2006.pdf)
- Beraldin, J.-A., Blais, F., Cournoyer, L., Picard, M., Gamache, D., Valzano, V., Bandiera, A., & Gorgoglione, M. (2006). Multi-resolution digital 3D imaging and modelling of the Grotta dei Cervi, at "The 7th International Symposium on Virtual Reality, Archaeology and Cultural Heritage (VAST 2006). Nicosia (Cyprus), 30/10-4/11/2006. Retrieved from [http://www.ceit-ottranto.it/images/documents/short\\_vast06.pdf](http://www.ceit-ottranto.it/images/documents/short_vast06.pdf)
- Beraldin, J.-A., Picard, M., El-Hakim, S., Godin, G., Borgeat, L., Blais, F., Pachet, E., Rioux, M., Valzano, V., & Bandiera, A (2006). Virtual reconstruction of heritage sites: opportunities and challenges created by 3D technologies. In *Proceedings of Recording, Modeling and Visualization of Cultural Heritage* (pp. 141-156). London: Taylor & Francis/Balkema. Retrieved from <http://www.ceit-ottranto.it/images/documents/nrc-48100.pdf>
- Beraldin, J.-A., Picard, M., El-Hakim, S.-F., Godin, G., Valzano, V., & Bandiera, A (2005). Combining 3D technologies for cultural heritage interpretation and entertainment. In *Proceedings of SPIE-IS&T Electronic Imaging 2005: Conferences Videometrics VIII*, San Jose, California (pp. 108-118). Bellingham, Washington: SPIE International Society for Optics and Photonics. Retrieved from [http://www.ceit-ottranto.it/images/documents/ei2005\\_paper.pdf](http://www.ceit-ottranto.it/images/documents/ei2005_paper.pdf)
- Beraldin, J.-A., Picard, M., Valzano, V., Bandiera, A., & Negro, F. (2011). Best practices for the 3D documentation of the Grotta dei Cervi of Porto Badisco, Italy. In *Proceedings of IS&T/SPIE Electronic Imaging 2011. Science and Technology* (pp. 78640J-78640J-15). San Francisco: International Society for Optics and Photonics. Retrieved from [http://www.ceit-ottranto.it/images/documents/paper\\_spie2011.pdf](http://www.ceit-ottranto.it/images/documents/paper_spie2011.pdf)
- Boero, F., Fogliini, F., Frascchetti, S., Goriup, P., Macpherson, E., Planes, S., Soukissian, T., & The CoCoNet Consortium (2016). CoCoNet: towards coast to coast networks of marine protected areas (from the shore to the high and deep sea), coupled with sea-based wind energy potential. *SCIRES-IT - SCientific RESearch and Information Technology*, 6(Supplement), 1-95. <http://dx.doi.org/10.2423/i22394303v6Sp1>
- Boero, F., Valzano, V., & Bartolomei, C. (2016). Editorial. A supplement of Scires-it on the COCONET european project. *SCIRES-IT - SCientific RESearch and Information Technology*, 6(Supplement), I-II. <http://dx.doi.org/10.2423/i22394303v6Sp1>
- Cariddi, P (2014). *Otranto intra moenia. Dagli aragonesi ad oggi*. Monteroni di Lecce, IT: Esperidi.
- Convegno *La Grotta dei Cervi di Porto Badisco in 3D. Una visita virtuale nel Castello di Otranto*. Otranto, 25-26/11/2010. Retrieved from <http://www.ceit-ottranto.it/images/grotta-cervi-convegno2010-vv.pdf>
- Graziosi, P. (2002). *Le pitture preistoriche della Grotta di Porto Badisco*. Firenze, IT: Rist. Anast. Istituto Italiano di Preistoria e protostoria.
- Gustapane, A. M. (2014). *Donna Teresa De Azvedeo*. Otranto, IT: Tipografia Hydruntum.
- Paiano, E., & Cazzato, M. (2000). *Nel mare più azzurro del Mediterraneo alla scoperta delle coste del Salento*. Galatina, IT: Congedo.

- Paquet, E., Peters, S., Beraldin, J.-A., Valzano, V., & Bandiera, A. (2003). Virtualization, virtual environments, and content-based retrieval of three-dimensional information for cultural applications. In *Proceedings of IS&T/SPIE 15th Annual Symposium, Electronic Imaging, Science and Technology*, vol. 5013 (pp. 137-147). Santa Clara (California, USA).
- Ricciardi, P. (2011). *Otranto le sue Chiese e Grotte*. Galatina, IT: Editrice Salentina.
- Rinaldi, R. (2014). Underwater 3D filming. *SCIRES-IT - SCientific RESearch and Information Technology*, 4(2), 1-16. <http://dx.doi.org/10.2423/i22394303v4n2p1>
- Valzano, V., (2015). *La Galleria del Castello dei Castromediano: Ricostruzione tridimensionale e rappresentazione virtuale. The Gallery of the Castromediano's Castle: Three-dimensional reconstruction and virtual representation*. Video-documentary. Lecce, IT: CEIT-University of Salento. Video-documentary ranked first nationally in the "e-Culture & Tourism" category of the Italian eContent Award 2015 and represented Italy at the World Summit Award 2015. Retrieved from [http://www.ceit-ottranto.it/video-files/galleria\\_cavallino/galleria\\_castello\\_castromediano\\_ita.mov](http://www.ceit-ottranto.it/video-files/galleria_cavallino/galleria_castello_castromediano_ita.mov); [http://www.ceit-ottranto.it/video-files/galleria\\_cavallino/gallery\\_castromediano\\_castle\\_eng.mov](http://www.ceit-ottranto.it/video-files/galleria_cavallino/gallery_castromediano_castle_eng.mov)
- Valzano, V., Bandiera, A., & Beraldin, J.-A. (2005). Realistic representations of cultural heritage sites and objects through laser scanner information. In *Proceedings of 10th international congress Cultural Heritage and new Technologies*, Vienna (pp. 1-12). Wien, AT: Phoibos Verlag. Retrieved from <http://www.ceit-ottranto.it/images/documents/paper-vienna2005.pdf>
- Valzano, V., Bandiera, A., Beraldin, J.-A., Blais, F., Cournoyer, M., Picard, M., Gamache, D., & Gorgoglione, M. (2007). Modellazione digitale 3D della Grotta dei Cervi. In *Atti del Convegno eArcom 07. Sistemi Informativi per l'Architettura* (pp. 606-609). Firenze, IT: Alinea. Retrieved from <http://www.ceit-ottranto.it/images/documents/earcom07.pdf>
- Valzano, V., Bandiera, A., Beraldin, J.-A., Picard, M., El-Hakim, S., Godin, G., Borgeat, L., Blais, F., Paquet, E., & Rioux, M. (2005). Fusion of 3D information for efficient modeling of cultural heritage sites with objects. In *Proceedings of XXth CIPA 2005 International Symposium*. Torino, IT; ACTA. Retrieved from [http://www.ceit-ottranto.it/images/documents/cipa2005\\_paper.pdf](http://www.ceit-ottranto.it/images/documents/cipa2005_paper.pdf)
- Valzano, V., Beraldin, J.-A., Bandiera, A., & Negro, F. (2009-2012). *Neolithic Mysteries: Revealing in 3D the Grotta dei Cervi of Porto Badisco* [DVD video]. Lecce, IT: Università del Salento & CASPUR. DVD video ranked first nationally in the "eScience and Technology" category of the Italian eContent Award 2009 and nominated for the World Summit Award 2011.
- Valzano, V., Negro, F., & Foschi, R. (2017). The Gallery of the Castromediano's Castle. Three-dimensional reconstruction and virtual representation. *SCIRES-IT - SCientific RESearch and Information Technology*, 7(2), 13-26. <http://dx.doi.org/10.2423/i22394303v7n2p13>
- Zeza, F. (2003). *La Grotta dei Cervi sul Canale d'Otranto. L'ambiente carsico ipogeo e stato di conservazione delle pitture parietali*. Lecce, IT: Capone Editore