The ORION Project
A European Union Thematic Network

Luis Salgado (*)
Nessa O'Connor (**)
Martha Tsapatori (***)
Jorge A. Soler (****)

* Grupo de Tratamiento de Imágenes
E.T.S.I. Telecomunicación
Univ. Politécnica de Madrid.
E-28040 Madrid, Spain
L.Salgado@gti.ssr.upm.es

** National Museum of Ireland.
Kildare St.
Dublin 2, Ireland
noconnor@museum.ie

*** Athens Technology Center.
10, Rizariou str, 152 33
Halandri, Athens, Greece
M.Tsapatori@atc.gr

**** MARQ
Museo Arqueológico
Provincial de Alicante.
Plaça. Dr. Gómez Ulla, s/n
E-03013 Alacant, Spain
jasoler@dip-alicante.es

Resumen

En este artículo se presenta un resumen de la evolución y los principales resultados obtenidos en el marco del Proyecto Europeo ORION, desarrollado entre Julio de 2002 y Junio 2003, y cuyo objetivo principal fue la constitución de una Red de expertos que permitiese crear una Hoja de Ruta para el desarrollo y empleo de la tecnología 3D en el marco de la arqueología y, más específicamente, en el de los museos arqueológicos.

Este resumen se plantea como un breve análisis de los principales resultados obtenidos en las diferentes etapas del proyecto – Revisión de las prácticas y necesidades de los museos arqueológicos y revisión científica y tecnológica –, etapas que dieron lugar a la configuración final de la Hoja de Ruta cuyas recomendaciones y conclusiones principales se resumen en la parte final de este artículo.

Para la consecución de estos objetivos se contó con un equilibrado Consorcio de 12 miembros de 7 países europeos, que agrupó tanto a museos y centros arqueológicos líderes en el empleo de las nuevas tecnologías – destacando el Museo Nacional de Escocia como líderes del proyecto, el Museo Nacional de Irlanda y el Museo Arqueológico Provincial de Alicante –, así como empresas y universidades de fuerte carácter tecnológico donde la responsabilidad técnica fue asumida por el Grupo de Tratamiento de Imágenes de la Universidad Politécnica de Madrid y la empresa Athens Technology Center.

Summary

In this article, a summary of the objectives, evolution and main achievements of the European Project ORION are presented. This project started in July 2002 and ended in June 2003 with a general objective of forming a Network of leading experts to create an informed and authoritative Research Roadmap for the development of 3D technology, literacy and usage in the framework of archaeology, and specifically in the context of the archaeological museums.

The summary is structured as a brief analysis of the main achievements obtained in the different phases of the project that conducted to the Research Roadmap design – museum practices and needs analysis and scientific and technology review -, together with a revision of the main recommendations and conclusions derived from that document.

To achieve the project goals, a well balanced Consortium was established. It is the core of the ORION Network and grouping a partnership of leading archaeological museums – National Museum of Scotland as project leader, National Museum of Ireland and the Archaeological Museum of Alicante, MARQ, among others – and technical institutions from 7 European countries – technical responsibility undertaken by the Grupo de Tratamiento de Imágenes of the Universidad Politécnica de Madrid, and the company Athens Technology Center in Greece.

Introduction

The world is filled with real and, increasingly, virtual objects. It is primarily through objects that people make sense of the world around them and it is primarily through objects that regions have defined themselves. Empowering users to "read" objects from different regions allows them to understand and

MARQ, ARQUEOLOGÍA y MUSEOS, 00
2005 : 103 - 112

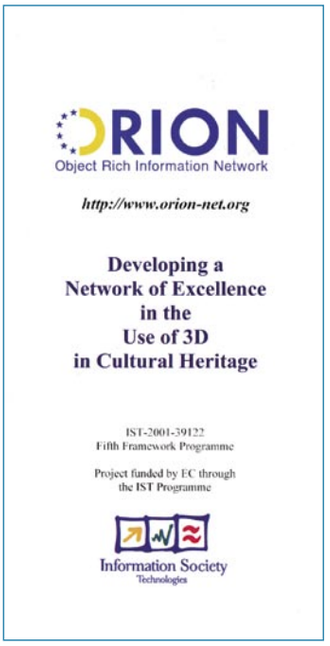

Figura 1. ORION. Brochure.

appreciate these objects and provides them with tools for understanding and appreciating regional diversity.

Emerging 3D technologies enable end-users to approach, examine all parts of objects in close detail, and offer unique opportunities to learn how to interpret objects and spaces in ways that promote both an understanding of the past and an illumination of the present.

As we move beyond the traditional text-and-image approach of the last decade, 3D literacy is becoming an increasingly important skill, playing a growing role in a range of fields, including education, design and engineering. Sophisticated 3D technologies and the skills they promote will be vital in enriching Europe's cultural, technological and industrial future. A natural forum in which to explore these issues is the museum environment, and particularly archaeological museums, as they have a unique relationship with 3D objects.

The ORION project

ORION (Object Rich InfOrmation Network) is a European Union funded Thematic Networks project started in July 2002 and finished in June 2003 with a general objective of forming a Network of leading experts which examine the business, technological and cultural landscape in the museum environment and the supporting educational and scientific communities, with special emphasis on the archaeological community, with the aim of identifying technology paths that will allow electronic, yet realistic, representation of museums' physical resources – both objects and sites – easily and effectively accessible from the wider public community.

Therefore, together with the objective of forming a Network of leading experts, the ultimate goal of ORION is to create an informed and authoritative Research Roadmap for the development of 3D technology, literacy and usage in Europe and beyond. This roadmap will help the EC to plan future research strategy and include assessment of *user requirements, 3D technology, Training, and Recommended Research Activities*.

The project Consortium

To achieve these goals, a well balanced Consortium was established. It is the core of the ORION Network and grouping a partnership of 12 leading archaeological museums and technical institutions from 7 European countries. More specifically:

Museums: National Museum of Scotland (Project Co-ordinator), National Museum of Ireland, Neanderthal Museum (Germany), Alicante Archaeological Museum (Spain), Archaeological Laboratories of Dion (Greece), and Centre Archéologique Européen du Mont Beuvray (France).

Technology and academic institutions: Athens Technology Centre (Greece), Universidad Politécnica de Madrid (Spain), University of Florence (Italy), The Multimedia Team (Scotland), Gessellshaft zur Foerderung Angewandter Informatik E.V. (Germany), and Intracom (Greece).

Figura 2. ORION. Members.

Project Research Activities

Three main research activities were conducted within the Project as contributions to the design of the Research Roadmap: the *Analysis of museum current practices and needs* (focused on archaeological museums), a *Scientific and technological review* (mainly focused on 3D technology), and the *Roadmap generation*.

The two first activities run in parallel for the first seven months of the Project, with special attention devoted to promote the synergy between the user requirements' analysis and the technological review activities through the periodic organization of meetings and workshops.

The last six months of the project were devoted to consolidate and synthesise the results from the previous research activities in order to design a Research Roadmap linking the needs and expectations of European archaeological museums in terms of 3D technologies and applications, and identifying several thematic areas considered essential for further research.

Network Expansion Activities

One of the main objectives of the project was to build up a balanced, structured network of business, technological and cultural partners with a direct interest in the development of 3D technology, literacy and usage in archaeology. For this purpose, more than ten national and international workshops were organised across Europe – London, Alicante, Edinburgh, Dublin, Dijon, Warsaw, Florence… – to discuss issues concerning the use of 3D in archaeology. These involved people from both technical backgrounds and those from the museum world, including the attendance of selected Friends of ORION, chosen on their expertise in specific areas related to the work of the project.

Additionally, the ORION progress and results were presented at many different international conferences – EVA (London 2002, Harvard 2002, Berlin 2002, Florence 2003…), EAA 2002 Thessaloniki, Amman Cultural Heritage (Amman, 2002), AIVA 2002 (Olympia, 2002), ICT eXPO Conference (Dublin, 2003), Med. Conf. on Cultural Turism 2003 (Catania, 2003), E-Way into the Four Dimensions of Cultural Heritage (Vienna, 2003), SPIE International Symp Optical Metrology (Munich, 2003), etc.

The result was the creation of the ORION Network, which included more than 100 members from different organizations located in Europe, North America and Asia.

Research Roadmap design

The ORION Research Roadmap is a combination of an industry and technology roadmap, focusing on the business and technological needs and priorities of the European archaeological museum's sector.

The development of the ORION Research Roadmap has been based on user needs, therefore following a "Backward Roadmapping" approach. The exercise involved finding out how to reach given targets set by the archaeological museum community.

ORION Roadmapping methodology is based on a step-based approach. Four different steps have been defined and consequently followed in order to identify the main areas for future research aiming to satisfy requirements of the archaeological museums, having as a basis the current practices and museum needs as well as the related scientific and technological state-of-the-art. The four steps were: Definition of the current picture in terms of museum practices and needs (Step 1), and in terms of scientific and technology state of the art (Step 2); research areas implementation plan and guidelines detailed definition (Step 3), and prioritization of research topics and recommendations for future research (Step 4).

A brief overview of the different outcomes is now presented in this article.

Museum practices and needs

The consultations with museums professionals and other key experts in the cultural sector highlighted great enthusiasm for 3D and great awareness of its potential. Around 65% of archaeological museums consulted said that 3D had an "important" or "very important" role to play in presenting archaeology to the public and in the study of material culture. This varied from around 50% in Spain to around 85% in Greece.

One relevant finding from our survey of European archaeological museums was just how many had already used 3D in presenting or promoting their collections, sites or museums. Around 35% of museums consulted had already used 3D in some form. This ranged from around 10% in Scotland to well over 50%in Germany. In many cases, this was only one initial presentation or project, but it gave a strong indication, born out by further responses, that museums are beginning to realize the potential that 3D offers.

Additionally, around 10% of museums consulted held some 3D images of their objects, and around 15% held 3D movies of sites. Again, the number of 3D resources held was generally very small, usually in single figures, but the fact that a significant number of museums consulted already have the beginnings of a 3D library illustrates a serious awareness of the growing relevance of 3D in the cultural sector.

Another positive finding was that around 45% of museums said that 3D was part of their future IT development strategy. In some cases, this involved specific identified projects. In other cases, it represented more of a declaration of intent. Again there was a variation across countries on this question, from around 35% in Scotland and France, to around 80% in Germany. Regardless of whether or not 3D was part of their institutions' present plans, there was almost universal consensus amongst museum professionals that certain uses of 3D in an archaeological museum context constituted a high priority.

Luis, I was going to add in here some of the range of possibilities for the use of 3D in Museums but then I read on and discovered that you had included them further on in the bullet points below. It covers the topics very well.

As general conclusions, it has been confirmed that there is a growing understanding and excitement within the museum community about the great benefits that 3D can offer museums across a wide range of areas.

Museums recognize that with the right investment and imagination, they can benefit massively from 3D in terms of increased educational potential, increase ease of undertaking core tasks, increased profitability and ultimately increased relevance in society.

3D is now featuring as part of IT strategy in a high proportion of museums and many figures in the European museum community believe that in the long-term 3D will play a crucial part in redefining the role of museums in the 21st century.

According to the expressed needs and expectations from the archaeological museums, the following key areas for future research were defined:

•3D scanning: it should be a standard stage in the process of acquiring an object, for reasons of cataloguing, conservation and security, and a key requirement of museum users is to know that affordable 3D scans of the objects are of a high enough standard to fulfil all their needs.

•Quality – High resolution 3D representations of archaeological artefacts: the use of high resolution, high quality 3D representations are required for professional examination of objects accessing the different parts of the objects, virtual exploration of objects and sites that no longer exist in their original form, comparison and classification.

•Object registration and content management: interoperability among various collections management systems for efficient data exchange is required, together with efficient joined-up processes and standards within the European museum community, from point of entry to the museum right through to display and digitization. Particular relevant is the need for protection of IPR of artefacts using watermarking techniques.

•Conservation – Restoration – Damage assessment for artifact transit and mobility: the use of 3D technologies and tools should allow the museum staff, including conservators, to conduct research con objects in museums' collections, explore various restoration possibilities facilitating decision making about the final restoration option, and for high value objects or objects going to a loan to other institutions, have accurate security and conservation information, vital in case of objects become damaged.

•Public access and education: among other relevant points, to achieve wider public access through the use of artefact 3D representations in museum exhibition spaces, web sites and other museum spaces used for educational purposes, combining objects and virtual environments, and allowing users to have online access to high quality 3D representations of most important cultural resources are considered.

•Scientific analysis tools: there is a clear need to have tools and applications that allow obtaining quick and accurate metric comparisons and evaluation of geometrical similarities / divergences / damages in object parts or findings, allowing also scientific exchange of data in an efficient way.

•Horizontal – Business issues: several aspects were pointed out as relevant under this area, covering the research into overcoming "soft" organizational behavioural barriers to 3D usage, research on image systems cost tracking and related studies, investigation into psychological and sociological behavior with regards to 3D objects, and globally, the development of culturally aware Centres of Excellence to disseminate information and advice about 3D to the museum community.

Scientific and Technology Review

In parallel to the identification of the museum practices and needs summarized in the previous section, the technology partners of the ORION Network have undertaken targeted research in specified fields in order to produce a report on technological trends and platforms applied in the environment of the archaeological museums and to recommend areas for future investment, training, research and development.

Based on the initial research activities of the Member Institutions, discussed in the ORION workshops with the technology partners of the consortium, different research topics identified (technologies and systems for 3D objects generation, presentation and management, and virtual and augmented reality technologies and applications) have been grouped into four major technological fields covering the while lifecycle of 3D objects - from the fundamentals for their generation up to their management and distribution-:

1. Background on computer generated 3D graphics: the main concepts related to 3D graphics were addressed, covering aspects such as 3D object and scene modelling, rendering techniques, and animation and behaviour modelling intrinsic to objects respecting user constraints.

2. Scene authoring: the fundamentals on how to create an interactive 3D scene were addressed, focusing on specific detailed points such as 3D object modelling through practical scanning, artist-based 3D object modelling, animation and behaviour modelling, scene composition, and techniques to incorporate behaviour and content access to the scene.

3. Scene experiencing: how the user can experience an interactive 3D scene was review, detailing the interactivity and immersiveness concepts in terms of existing software tools and hardware systems which allow virtual and augmented reality applications to be developed.

4. Content management: the alternatives to integrate and manipulate 3D objects in a structured way were in depth analyzed according to user requirements in terms of quality, flexibility and functionality information. Particular topics such as 3D object coding, database management for 3D object collections, 3D objects exhibition applications, network and communication platforms, and issues related to the Intellectual Property Rights of 3D objects were addressed.

As a result of this analysis, the degree of maturity of the most relevant scientific and technological issues was considered and it was proposed that broaden and supplementary efforts should be considered for the following scientific / technological fields:

•3D scanning: further research efforts are necessary in terms of implementing outdoor scanning devices (mobile / on-site scanners), also on the scanning devices properties (integrated object colour measurement, surface light reflection models,…), and on the data format standards to cater for interoperability issues along the various scanning and post-scanning processes as well as for data re-use in other applications.

•3D representation of objects and sites: further research efforts are necessary in terms of better definition of 3D object attributes so as to achieve realistic representations of objects - radiosity, shadows, reflections/refractions -, as well as in the area of 3D object animation -bone-based animation, inverse kinematics or behavioural animation-

•Object registration and content management: research should focus on content management and dissemination – context based search engines, cultural metadata definitions, web portals for culture incorporating virtual and augmented reality, authoring tools, network availability …-, feature-based search and retrieval of 3D objects, and very specially, digital watermarking tools for 3D models.

•Technology / Research standards: several research works have been presented very good results in this area but there is still area for further efforts mainly in terms of object registration and archiving.

Research Roadmap recommendations

Based on the results of the definition of the current picture in terms of museum needs and scientific / technology state-of-the-art, a detailed implementation plan and guidelines for the future implementation of each one of the areas identified as crucial for future research has been produced. Different aspects are addressed such as the priority and time horizon for the implementation of the different research topics, and an estimation of the level of participation expected from different types of organizations (Public authorities, Museums, Universities, etc).

In the last step of the research roadmapping strategy, for each research topic identified, different recommendations are provided. They are based on the estimation of each research topic feasibility and associated priority, and can be summarized as follows.

3D scanning

As related inquiries in different European museums prove, existing solutions for 3D scanning mostly do not yet match the needs and requirements of widespread and intense use for object registration and object management in museums, though particularly such usage is requested and appreciated for reasons of both new, extended possibilities / quality and economy /efficiency.

Different to technical or engineering applications of 3D scanning and modelling, museums need highly automated and simple-to-use solutions, which should integrate measurements and handling of surface properties like colour, texture, and level of opacity.

For that reason, it is recommended to support the development of fit-for-purpose 3D scanning and modeling solutions, which could solve specific museums requirements.

Quality – High resolution 3D representations of archaeological artifacts

There is still a large gap to be bridged between what users in the culture and heritage fields expect visually and what is currently achievable. This is also true for the public domain where there is a genuine interest in the work that museums do. The images have to be realistic and readable in order to be interpreted. This is a daunting task considering the huge variations in the types of artefacts in current collections, as well as the large number of new discoveries that are made each year.

To gather information on the quality standards currently available and those required, more extensive scanning trials need to be undertaken. This will require museums to offer up a wide range of materials for scanning and for them to be actively involved in evaluating the quality and usefulness of the resulting 3D models and associated file outputs.

As 3D imagery becomes part of our everyday lives in the way that 2D currently is, the quality of image expected from 3D will understandably be very high. Only by increasing the volume and use of 3D images in a variety of sectors can we improve visual literacy, and the archaeological world would be an ideal place to start.

Object Registration & Content Management

In this complex field, a group of different tasks were identified including relational database architectures, intelligent search algorithms, museum-related information standards (object descriptive terms, conceptual models) with metadata descriptions, seamless integration of advanced multimedia user interfaces for the use of virtual and mixed reality techniques, and digital encryption techniques.

These tasks clearly indicate the need for collaboration between archaeologists, scientists and technology experts, each one devoting a significant amount of effort to understand each other's needs and direct the research in a common direction where the object registration process and the management of the digital resources will serve the needs of a fully digitized museum and archaeological excavation.

Conservation – Restoration – Damage assessment for artefact transit and mobility

There is a great deal of potential for the effective application of customized 3D research design to meet the practical requirements of archaeological museums across a wide range of essential operations. In this section, the Research Roadmap provides details of the range of museum applications which could be greatly facilitated by further original and applied research on 3D usage, drawing upon experience of both technical and museum partners. Examples of these applications are: 3D and routine archaeological conservation;

conservation records; virtual access for the public to archaeological conservation; damage assessment; 3D usage to track artifact theft and illicit import and export of antiquities; 3D and artifact restoration; and 3D as an excavation tool – recording artefact context, virtual preservation of physical features.

3D could be especially effective in fine-tuning specialist procedures involved in for example, osteoarchaeology, site recording and post-excavation analyses.

These processes are often extremely expensive because of the amount of experts' time required to complete recording rather than analysis.

Public access and Education

Museums should try to make use of their available digital resources and digitized content for a variety of applications. The prominent application is edutainment, which consists of the implementation of virtual collections for on-line and interactive on-site visiting, education of school and university students and dissemination of cultural heritage to the wider public. For these applications the research components identified in the different areas within the Research Roadmap are needed together with a clear view on educational and recreational usage scenarios.

Museum staff should be kept updated on the latest technology developments and seek collaborations with other institutions and museums. Currently, research efforts are directed towards these directions but there is a long way to go before these systems reach maturity.

Scientific analysis tools

Museums provide unique possibilities for research in human and social sciences. The availability of accurate virtual object representations and the possibility of exchanging them opens a wide range of new analysis methods which may deepen the understanding of human and earth history and may lead to new discoveries from the analysis of the known objects.

In this frame algorithms and methods for comparison of pieces and findings, actually located in different distant places and the metric evaluation of complex shaped geometry parts, together with virtual process modelling considering, for example, ancient manufacturing tools and methods, virtual puzzling of pieces using macro and micro geometry and available texture information, or virtual simulation of wear and weathering deformations for analysis goals, virtual resistance and stability analysis are of particular high interest.

Conclusions

In this paper, a brief overview of the ORION Project evolution and major achievements has been presented. Particularly relevant was the effectiveness of the technical/curatorial composition of the Consortium,

that allows a high amount of research work achieved in a very short project time (1 year), and the strong desire of the Consortium to have an opportunity to prioritise the most promising aspects of the Research Road Map findings.

In this process, it has been clear that besides the museum actors several other stakeholders should be involved. As such, universities (of technological as well as of sociology studies), large and smaller companies active in the cultural applications domain, research institutes and governmental bodies have a key role to play, in order to ensure fruitful results.

A key issue in order to achieve successful implementation results in the future is the issue of cost and financial resources in general. It is well known that the museum community at a European (even at an international) level lacks of the financial resources to invest in novel technologies. Hence, it is imperative that the museums, accompanied by the scientific and technological community, put a special focus on the implementation of low-cost solutions keeping at the same time the optimum level of quality.

ORION project has demonstrated the path to the archaeological museums towards this direction by proposing scientific / technological research combined with an examination of the wider societal and financial barriers towards the integration of 3D technologies and applications into the museums environment.

Bibliografía

ORION Consortium: "Report on current practices and needs". *External Deliverable*, *D5*. ORION Project, 2003.

ORION Consortium: "Report on Scientific / Technological Trends and Platforms". *External Deliverable*, *D6*. ORION Project, 2003.

ORION Consortium: "Dissemination, Extension and Enlargement plan", *Internal Deliverable*, *D7*. ORION Project, 2003

ORION Consortium: "Research Roadmap", *External Deliverable*, *D8*. ORION Project, 2003.