GUIDELINES & CASE STUDIES

3D ICONS

cip competitiveness and innovation framework programme 2007–2013

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INTRODUCTION

Public fascination with the architectural and archaeological heritage is well known, it is proven to be one of the main reasons for tourism according to the UN World Tourism Organisation. Historic buildings and archaeological monuments form a significant component Europe's cultural heritage; they are the physical testimonies of European history and of the different events that led to the creation of the European landscape, as we know it today.

The documentation of built heritage increasingly avails of 3D scanning and other remote sensing technologies, which produces digital replicas in an accurate and fast way. Such digital models have a large range of uses, from the conservation and preservation of monuments to the communication of their cultural value to the public. They may also support in-depth analysis of their architectural and artistic features as well as allow the production of interpretive reconstructions of their past appearance.

The goal of the 3D-ICONS project, funded under the European Commission's ICT Policy Support Programme which builds on the results of CARARE (www.carare.eu) and 3D-COFORM (www.3d-coform.eu), is to provide Europeana with 3D models of architectural and archaeological monuments of remarkable cultural importance. The project brings together 16 partners (see appendix 2) from across Europe (11 countries) with relevant expertise in 3D modelling and digitization. The main purpose of this project is to produce around 4000 accurate 3D models which have to be processed into a simplified form in order to be visualized on low end personal computers and on the web.

THE STRUCTURE OF THIS PUBLICATION HAS BEEN CREATED WITH TWO DISTINCT SECTIONS:
Guidelines: Documentation of the digitisation, modelling and online access pipeline for the creation of online 3d models of cultural heritage objects.
Case Studies: 28 examples of 3D content creation by the 3D-ICONS partners across a range of monuments, architectural features and artefacts.

GREYSCALE RADIANCE SCALING SHADED VERSION OF THE CHURCH OF THE HOLY APOSTLES 3D MODEL

IMAGE OF 3D CAPTURED DATA E.G. POINT CLOUD, MESH MODEL OF CHRYSIPPUS HEAD

THE CENACLE COMPLEX - XRAY FILTER VIEW RE-COLOURED, GENERATED BY MESHLAB

GUIDELINES

The 3D-ICONS project exploits existing tools and methodologies and integrates them in a complete supply chain of 3D digitization to contribute a significant mass of 3D content to Europeana. These guidelines aim to document this complete pipeline which covers all technical and logistic aspects to create 3D models of cultural heritage objects with no established digitization.

Each section of these guidelines corresponds to one of the five interlinked stages of the 3D-ICONS pipeline:

1. 3D Data Capture Techniques
2. Post Processing of 3D Content
3. 3D Publishing Methodology
4. Metadata
5. Licensing & IPR Considerations

When reading the guidelines it is important to understand that each stage in the processing pipeline is interrelated, and therefore one should look at the pipeline as a holistic approach to the challenge of capturing and presenting 3D models of cultural heritage models. Data capture, post processing and 3D publishing activities normally occur sequentially after each other.

The direction of these activities is not only towards the final online 3D model. In carrying out your own 3D heritage efforts, one should also consider the final potential publishing methodology, and travel back up the supply chain to identify what are the most appropriate capture and modelling techniques to provide this online 3D solution. The processes involved with the creation of metadata and the selection of appropriate data licensing should be integrated at all stages of the pipeline.

These guidelines are a product of the effort of all project partners' and are the synthesis of several project publications (see appendix 1) which can be consulted for in-depth documentation of the different components of the pipeline. The guidelines do not represent an exhaustive list of all the potential processing paths but provide, describe and explore the solutions provided by the 3D-ICONS project.

3D DATA CAPTURE TECHNIQUES

In recent years the development of technologies and techniques for the surface data capture of three-dimensional artefacts and monuments has allowed both geometrical and structural information to be documented. Several approaches have been developed, each of which addresses different circumstances and records different characteristics of the 3D artefact or monument.

At present there is a wide range of 3D acquisition technologies, which can be generally classified into contact and non-contact systems. Contact systems are not popular in the Cultural Heritage (CH) domain as they require physical contact with potentially fragile artefacts and structures.
In contrast, non-contact systems have been used over the last decade in many CH digitisation projects with success. Non-contact systems are divided into active (those which emit their own electromagnetic energy for surface detection) and passive (those which utilise ambient electromagnetic energy for surface detection).

TAXONOMY OF 3D DATA CAPTURE TECHNIQUES

Active range-sensing instruments work without contact with the artefact and hence fulfil the requirement that recording devices will not potentially damage the artefact. In addition, their luminous intensity is limited to relatively small values and thus does not cause material damage (e.g. by bleaching pigments). These two properties make them particularly adapted for the applications in CH, where non-invasive and non-destructive analyses are crucial for the protection of heritage.

The capabilities of the different technologies vary in terms of several criteria which must be considered and balanced when formulating appropriate campaign strategies. These include:

- **Resolution** – the minimum quantitative distance between two consecutive measurements.
- **Accuracy** - what is the maximum level of recorded accuracy?
- **Range** – how close or far away can the device record and object?
- **Sampling rate** – the minimum time between two consecutive measurements?
- **Cost** – what is the expense of the equipment and software to purchase or lease?
- **Operational environmental conditions** – in what conditions will this method work, i.e. is a dark working environment required?
- **Skill requirements** – is extensive training required to carry out the data capture technique?
- **Use** – what the 3D data will be used for, i.e. scientific analysis or visualisation?
- **Material** – from what substance is the artefact/monument fabricated?

There are significant variations between the capabilities of different approaches. For example, triangulation techniques can produce greater accuracy than time-of-flight, but can only be used at relatively short range. Where great accuracy is a requirement, this can normally only be achieved with close access to the heritage object to be digitized (< 1m). If physical access to the artefact is difficult or requires the construction of special scaffolding, other constraints need consideration (e.g. using an alternative non-invasive techniques). Alternatively, if physical access is impractical without unacceptable levels of invasive methods, then sensing from a greater distance maybe required utilising direct distance measurement techniques (TOF, Phase Deviation) leading to less accurate results. When selecting the appropriate methodology, consideration must also be given to the length of time available to carry out the data collection process and the relative speed of data capture of each technology.

SHORT RANGE TECHNIQUES

LASER TRIANGULATION (LT)

One of the most widely used active acquisition methods is Laser Triangulation (LT). The method is based on an instrument that carries a laser source and an optical detector. The laser source emits light in the form of a spot, a line or a pattern on the surface of the object while the optical detector captures the deformations of the light pattern due to the surface's morphology. The depth is computed by using the triangulation principle. Laser scanners are known for their high accuracy in geometry measurements (<50µm) and dense sampling (<100µm). Current LT systems are able to offer perfect match between distance measurements and colour information. The method being used proposes the combination of three laser beams (each with a wavelength close to one of the three primary colours) into an optical fibre. The acquisition system is able to capture both geometry and colour using the same composite laser beam while being unaffected by ambient lighting and shadows.

DIAGRAM ILLUSTRATING THE PRINCIPLES OF LASER TRIANGULATION (LT) BASED RANGE DEVICES

STRUCTURED LIGHT (SL)

Structured Light (SL) - also known as fringe projection systems - is another popular active acquisition method that is based on projecting a sequence of different alternated dark and bright stripes onto the surface of an object and extracting the 3D geometry by monitoring the deformations of each pattern. By examining the edges of each line in the pattern, the distance from the scanner to the object's surface is calculated by trigonometric triangulation. Significant research has been carried out on the projection of fringe patterns that are suitable for maximizing the measurement resolution. Current research is focused on developing SL systems that are able to capture 3D surfaces in real-time. This is achieved by increasing the speed of projection patterns and capturing algorithms.

DIAGRAM ILLUSTRATING THE PRINCIPLES OF STRUCTURED LIGHT (SL) MEASUREMENT DEVICES

LONG & MID RANGE TECHNIQUES

TIME OF FLIGHT (TOF)

Time-Of-Flight (TOF) - also known as terrestrial laser scanning - is an active method commonly used for the 3D digitisation of architectural heritage (e.g. an urban area of cultural importance, a monument, an excavation, etc). The method relies on a laser rangefinder which is used to detect the distance of a surface by timing the round-trip time of a light pulse. By rotating the laser and sensor (usually via a mirror), the scanner can scan up to a full 360 degrees around itself. The accuracy of such systems is related to the precision of its timer. For longer distances (modern systems allow the measurement of ranges up to 6km), TOF systems provide excellent results. An alternative approach to TOF scanning is Phase-Shift (PS), also an active acquisition method, used in closer range distance measurements systems. Again they are based on the round trip of the laser pulse but instead of timing the trip they measure the wavelength phase difference between the outgoing and return laser pulse to provide a more precise measurement.

DIAGRAM ILLUSTRATING THE PRINCIPLES OF TIME OF FLIGHT (TOF) MEASUREMENT DEVICES

DIAGRAM ILLUSTRATING THE PRINCIPLES OF PHASE SHIFT (PS) MEASUREMENT DEVICES

MULTI SCALE IMAGE BASED METHODS

TRADITIONAL PHOTOGRAMMETRY

Image-based methods can be considered as the passive version of SL. In principle, image-based methods involve stereo calibration, feature extraction, feature correspondence analysis and depth computation based on corresponding points. It is a simple and low cost (in terms of equipment) approach, but it involves the challenging task of correctly identifying common points between images. Photogrammetry is the primary image-based method that is used to determine the 2D and 3D geometric properties of the objects that are visible in an image set. The determination of the attitude, the position and the intrinsic geometric characteristics of the camera is known as the fundamental photogrammetric problem. It can be described as the determination of camera interior and exterior orientation parameters, as well as the determination of the 3D coordinates of points on the images. Photogrammetry can be divided into two categories. These are the aerial and the terrestrial photogrammetry.

In aerial photogrammetry, images are acquired via overhead shots from an aircraft or an UAV, whilst in terrestrial photogrammetry images are captured from locations near or on the surface of the earth. Additionally, when the object size and the distance between the camera and object are less than 100m then terrestrial photogrammetry is also defined as close range photogrammetry. The accuracy of photogrammetric measurements is largely a function of the camera's optics quality and sensor resolution. Current commercial and open photogrammetric software solutions are able to quickly perform tasks such as camera calibration, epipolar geometry computations and textured map 3D mesh generation. Common digital images can be used and under suitable conditions high accuracy measurements can be obtained. The method can be considered objective and reliable. Using modern software solutions it can be relatively simple to apply and has a low cost. When combined with accurate measurements derived from a total station for example it can produce models of high accuracy for scales of 1:100 and even higher.

OVERLAPPING AREA OF IMAGES CAPTURED AT A AND B ARE RESOLVED WITHIN THE 3D MODEL SPACE TO ENABLE THE PRECISE AND ACCURATE MEASUREMENT OF THE MODEL

THE BASIC PRINCIPLE OF STEREO PHOTOGRAMMETRY. THE BUILDING APPEARS IN TWO IMAGES, TAKEN AT L AND L2 RESPECTIVELY. THE TOP OF THE BUILDIING IS REPRESENTED BY THE POINTS A1 AND A2 AND THE BASE BY B1 AND B2

SEMI AUTOMATED IMAGE BASED METHODS

In recent times, the increase in the computation power has allowed the introduction of semi automated image-based methods. Such an example is the combination of Structure-From-Motion (SFM) and Dense Multi-View 3D Reconstruction (DMVR) methods. They can be considered as the current extension of image-based methods. Over the last few years a number of software solutions implementing the SFM-DMVR algorithms from unordered image collections have been made available to the broad public. More specifically SFM is considered an extension of stereo vision, where instead of image pairs the method attempts to reconstruct depth from a number of unordered images that depict a static scene or an object from arbitrary viewpoints.

Apart from the feature extraction phase, the trajectories of corresponding features over the image collection are also computed. The method mainly uses the corresponding features, which are shared between different images that depict overlapping areas, to calculate the intrinsic and extrinsic parameters of the camera. These parameters are related to the focal length, the image format, the principal point, the lens distortion coefficients, the location of the projection centre and the image orientation in 3D space. Many systems involve the bundle adjustment method in order to improve the accuracy of calculating the camera trajectory within the image collection, minimise the projection error and prevent the error-built up of the camera position tracking.

DIAGRAM ILLUSTRATING THE PRINCIPLES OF STRUCTURE FROM MOTION (SFM) MEASUREMENT FROM MULTIPLE OVERLAPPING IMAGES

EXAMPLE OF SFM METHODOLOGY ILLUSTRATION THE ORIENTATION AND NUMBER OF OVERLAPPING IMAGES UTILISED IN THE MODELING OF A BUILDING (CETI)

THE RESULTING 3D POINT CLOUD DATA SETS DERIVED USING SFM (CETI)

SOFTWARE	COMMENTS
Automatic Reconstruction Conduit ARC 3D www.arc3d.be	Web-service where the user uploads an image collection and the system returns a dense 3D reconstruction of the scene. The resulting 3D reconstruction is created using cloud computing technology and can be parsed by Meshlab
123D Catch (Autodesk) www.123dapp.com/catch	Service is a part of a set of tools that are freely offered by the company and aim towards the efficient creation and publishing of 3D content on the Web. Their service can be accessed by a dedicated 3D data viewing-processing software tool that recently has been made available for the iOS mobile platform
Hypr3D (Viztu Technologies) www.hypr3d.com	Web-based 3D reconstruction from images service. The user can upload the images through the Website's interface without the need of downloading any standalone software application
PhotoModeler Scanner (Eos Systems) www.photomodeler.com	Reconstructs the content of an image collection as a 3D dense point cloud but it requires the positioning of specific photogrammetric targets around the scene in order to calibrate the camera
Insight3D insight3d.sourceforge.net	Open source solution to create 3D models from photographs. The software doesn't provide a DMVR option, but allows the user to manually create low complexity 3D meshes that can be textured automatically (image back-projection) by the software
PhotoScan (Agisoft) www.agisoft.ru	SFM-DMVR software solution can merge the independent depth maps of all images and then produce a single vertex painted point cloud that can be converted to a triangulated 3D mesh of different densities
Pix4D pix4d.com	Software is able to create 3D digital elevation models from image collections captured by UAVs. The software is being offered as a standalone application or as a Web-service

THERE ARE MANY INSTANCES OF SFM AND DMVR SOFTWARE WHICH ARE SUMMARISED IN THE TABLE ABOVE

POST PROCESSING OF 3D

3D post-processing is a complex procedure consisting of a sequence of processing steps that result in the direct improvement of acquired 3D data (by laser scanning, photogrammetry), and its transformation into visually enriched (and in some cases semantically structured) geometric representations. Post-processing also allows the creation of multiple 3D models starting from the same gathered data according to the desired application, level of detail and other additional criteria. The results of the post-processing phase are 3D geometric representations accompanied by complementary 2D media, which are the digital assets ready to be converted (or embedded) into the final web publishing formats.

POST-PROCESS A - GEOMETRIC RECONSTRUCTION

Geometric reconstruction is the essential processing step for the elaboration of a 3D representation of an artefact or monument following the capture of 3D digitisation. This can be achieved using several relevant techniques which must be chosen based upon:

- The morphological complexity of the object (from geometric primitives to organic shapes)
- The scale of the object
- What the final model will be used for (ranging from metric analysis to public dissemination)

AUTOMATIC MESHING FROM A DENSE 3D POINT CLOUD

The simple criteria for choosing and evaluating a relevant 3D geometric reconstruction technique is the degree of consistency of the 3D model compared to the real object. These guidelines are primarily concerned with the creation of 3D models from digitised data therefore this processing method will focus upon the automated meshing of 3D data from point-cloud data. However, additional methods are available for the 3D reconstruction, including (in order of level of approximation to reality):

- Interactive or semi-automatic reconstruction based on relevant profiles
- Interactive or semi-automatic reconstruction based on primitives adjustment
- Interactive reconstruction based on technical iconography (plans, cross-sections and elevations)
- Interactive reconstruction based on artistic iconography (sketches, paintings, etc.)

POINT CLOUD DATA

Once an artefact and monuments has been digitised the initial results (raw data) can be represented by a series of three dimensional data points in a coordinate system commonly called a point cloud. The processing of point clouds involves cleaning and the alignment phases. The cleaning phase involves the removal of all the non-desired data. Non-desired data would include the poorly captured surface areas (e.g. high deviation between laser beam and surface's normal), the areas that belong to other objects (e.g. survey apparatus, people), the outlying points and any other badly captured areas.

Another common characteristic of the raw data is noise. Noise can be described as the random spatial displacement of vertices around the actual surface that is being digitised. Compared to active scanning techniques such as laser scanning, image based techniques suffer more from noise artefacts. Noise filtering is in an essential step that requires cautious application as it effects the fine morphological details been described by the data.

IMAGE OF INTENITY SHADED POINT CLOUD MODEL OF CAHERGAL STONE FORT (DISCOVERY PROGRAMME)

PROCESSING MESH DATA

The next stage in the processing pipeline is the production of a surfaced or "wrapped" 3D model. The transformation of point cloud data into a surface of triangular meshes is the procedure of grouping triplets of point cloud vertices to compose a triangle. The representation of a point cloud as a triangular mesh does not eliminate the noise being carried by the data. Nevertheless, the noise filtering of a triangular mesh is more efficient in terms of algorithm development due to the known surface topology and the surface normal vectors of the neighbouring triangles. Several processes must be completed to produce a topologically correct 3D mesh model.

IMAGE OF POINT CLOUD DATA SET AND SUBSEQUENT DERIVED MESH MODEL (DISCOVERY PROGRAMME)

MESH CLEANING

Incomplete or problematic data from digitising an object in three dimensions is another common situation. Discontinuities (e.g. holes) in the data are introduced in each partial scan due to occlusions, accessibility limitation or even challenging surface properties. The procedure of filling holes is handled in two steps. The first step is to identify the areas that contain missing data. For small regions, this can be achieved automatically using currently available 3D data processing software solutions. However, for larger areas significant user interaction is necessary for their accurate identification. Once the identification is completed, the reconstruction of the missing data areas can be performed by using algorithms that take into consideration the curvature trends of the holes boundaries. Filling holes of complex surfaces in not a trivial task and can only be based on assumptions about the topology of the missing data. Additional problems identified in a mesh may include spikes, unreferenced vertices, and non-manifold edges, and these should also be removed during the cleaning stage. Meshing software (such as Meshlab or Geomagic Studio) has several routines to assist in the cleaning of problem areas of meshes.

ILLUSTRATION OF THE IDENTIFICATION AND CLOSING OF HOLES WITHIN THE 3D MESH MODEL (DISCOVERY PROGRAMME)

MESH SIMPLIFICATION

The mesh simplification, also known as decimation, is one of the most common approaches in reducing the amount of data needed to describe the complete surface of an object. In most cases the data produced by the 3D acquisition system includes vast amounts of superfluous points. As a result, the size of the raw data is often prohibitive for interactive visualisation applications, and hardware requirements are beyond the standard computer system of the average user.

Mesh simplification methods reduce the amount of data required to describe the surface of an object while retaining the geometrical quality of the 3D model within the specifications of a given application. A popular method for significantly reducing the number of vertices of a triangulated mesh, while maintaining the overall appearance of the object, is the quadric edge collapse decimation. This method merges the common vertices from adjacent triangles that lie on flat surfaces, aiming to reduce the polygons number without sacrificing significant details from the object. Most simplification methods can significantly improve the 3D mesh efficiency in terms of data size.

ILLUSTRATION OF HIGH RESOLUTION POLYGON MESH MODEL AND SIMPLIFIED LOW POLYGON MESH MODEL (DISCOVERY PROGRAMME)

MESH RETOPOLOGISATION

Extreme simplification of complex meshes, such as for use in computer games and simulations, usually cannot be done automatically. Important features are dissolved and in extreme conditions even topology is compromised. Decimating a mesh at an extreme level can be achieved by an empirical technique called retopology. This is a 3D modelling technique, where special tools are used by the operator to generate a simpler version of the original dense model, by utilising the original topology as a supportive underlying layer. This technique keeps the number of polygons at an extreme minimum, while at the same time allow the user to select which topological features should be preserved from the original geometry. Retopology modelling can also take advantage of parametric surfaces, like NURBS, in order to create models of infinite fidelity while requiring minimum resources in terms of memory and processing power. Some of the commonly available software that can be used to perform the retopology technique include: 3D Coat, Mudbox, Blender, ZBrush, GSculpt, Meshlab Retopology Tool ver 1.2. Mesh retopologisation can be a time consuming process, however, it produces better quality light weight topology than automatic decimation. It also facilitates the creation of humanly recognizable texture maps.

IMAGE ILLUSTRATING A LOW POLYGON MESH BEFORE (LEFT) AND AFTER RETOPOLOGISATION (LEFT)

TEXTURE MAPPING

Modern rendering technologies, both interactive and non-interactive, allow the topological enhancement of low complexity geometry with special 2D relief maps, that can carry high frequency information about detailed topological features such as bumps, cracks and glyphs. Keeping this type of morphological features in the actual 3D mesh data requires a huge amount of additional polygons. However, expressing this kind of information as a 2D map and applying it while rendering the geometry can be by far more efficient. This can be achieved by taking advantage of modern graphics cards hardware and at the same time keeping resource requirements at a minimum. Displacement maps are generated using specialised 3D data processing software, e.g. the open source software xNormal. The software compares the distance from each texel on the surface of the simplified mesh against the surface of the original mesh and creates a 2D bitmap-based displacement map.

DIAGRAM ILLUSTRATING THE DIFFERENT TEXTURE MAPS WHICH CAN BE EMPLOYED TO ENHANCE THE DISPLAY OF A LIGHTWEIGHT 3D MODEL. FROM TOP: UV MAP, NORMAL MAP, IMAGE MAP AND AMBIENT OCCLUSION MAP (DISCOVERY PROGRAMME)

POST-PROCESS B - MODEL STRUCTURING

Depending on the scale and on the morphological complexity, a geometric 3D reconstruction of an artefact, architectural detail or an archaeological site generally leads to the representation of a single (and complex) geometric mesh or a collection of geometric entities organized according to several criteria. The model structuring strategy is usually carried out with the aim of harmonizing the hierarchical relations, which can express the architectural composition of a building (e.g. relations between entities and layouts) and can also be used as a guideline for structuring the related metadata. In some cases, it may be important to identify a domain expert to ensure the consistency of the chosen segmentation (e.g. temporal components) and nomenclature (e.g. specialized vocabulary) is coherent with archaeological and architectural theories.

EXAMPLES OF GEOMETRIC RECONSTRUCTION TECHNIQUES (CNRS-MAP)

According to the technique used and to the general purpose of the 3D representation, the results of a geometric reconstruction can be structured in four ways:

1. Single unstructured entity (e.g. dense point clouds, or detailed mesh)
2. Decomposed in elementary entities (e.g. 3D models composed by few parts)
3. Decomposed in elementary entities hierarchically organized (e.g. 3D models decomposed in several parts for expressing the architectural layouts)
4. Decomposed in entities organized in classes (e.g. 3D models decomposed in several parts for expressing the classification of materials, temporal states, etc.)

According to the chosen model structuring strategy, the final dataset structure (including geometry and visual enrichment) can be composed in several ways.

EXAMPLE OF 3D MODEL STRUCTURING (CNRS-MAP) : ON THE LEFT, ACCORDING TO TEMPORAL STATES; ON THE RIGHT, ACCORDING TO A MORPHOLOGICAL SEGMENTATION (ARCHITECTURAL UNITS) (CNRS-MAP)

3D GEOMETRY

- Single structured 3D file - with one level of detail
- Multiple independent 3D files - with one level of detail
- Multiple independent 3D files - with multiple level of detail

TEXTURES

- Embedded into the 3D geometry file e.g. per vertex colour
- Stored as external 2D files e.g. UV maps

POST PROCESS C - VISUAL ENRICHMENT OF 3D MODELS

Several computer graphics techniques can be utilised for the visual enhancement of the 3D models produced from the geometric reconstruction processes. These guidelines focus on those techniques which provide a 3D simulation consistent with the visual and geometric characteristics of artefacts and monuments (reality capture) and other techniques, mainly used for the dissemination of 3D cultural data. The visual enrichment techniques described below are ordered from those that ensure a strong geometric consistency with the real object to techniques that introduce increasing approximations:

- Texture extraction and projection starting from photographs finely oriented on the 3D model (e.g. image-based modelling, photogrammetry)
- Texturing by photographic samples of the real materials of the artefact
- Texturing by generic shaders
- Interactive or semi-automatic reconstruction based on relevant profiles
- Interactive or semi-automatic reconstruction based on primitives adjustment
- Interactive reconstruction based on technical iconography (plans, cross-sections and elevations)
- Interactive reconstruction based on artistic iconography (sketches, paintings, etc.)

EXAMPLE OF VISUAL ENRICHMENT BASED ON THE PROJECTION OF TEXTURES STARTING FROM PHOTOGRAPHS FINELY ORIENTED ON TO A PRIMITIVES 3D MODEL (LEFT) AND THE PROJECTION OF PANORAMIC IMAGERY ON ORGANIC 3D MESHES (RIGHT) (CNRS-MAP / DISCOVERY PROGRAMME)

POST PROCESS D - HYPOTHETICAL RECONSTRUCTION

The hypothetical reconstruction of an architectural object or archaeological site to a previous state is a process primarily related to field of historical studies. Nevertheless, some specific technical and methodological issues with 3D graphical representation of missing (or partially destroyed) heritage buildings are often integrated in 3D reconstruction approaches. While primarily related to the analysis of historical images and knowledge, the methodological approaches for the creation of hypothetical reconstructions can be based on the integration of 3D metric data of existing parts of the object together with the reconstruction of the object's shapes starting from graphical representations of the artefact/monument. Depending upon the source material available 3D may be created based upon a combination of the following methods:

- the 3D acquisition of existing (or existed) parts
- previous 2D surveys of existing (or existed) parts
- non-metric iconographic sources of the studied artefact
- iconographic sources (metric and / or non-metric) related to similar artefacts

In addition where reconstructions are created the following recommendations should be taken into account:

- Identify the scientific advisor(s) who can guide and validate the 3D model during its reconstruction
- Document information about additional sources (imagery and bibliographical references) utilised in the elaboration of the 3D model
- Clearly indicate and save information indicating the degree of uncertainty e.g. information gaps within the 3D model.

EXAMPLE OF 3D HYPOTHETICAL RECONSTRUCTION OF A PAST STATE (CNRS-MAP)

CREATING COMPLEMENTARY 2D MEDIA (DERIVED FROM THE 3D MODEL)

During the creation of 3D models of artefacts complementary 2D media can also be produced. This 2D media can be produced in different ways, depending on the type of 3D source (point cloud, geometric model, visually enriched 3D model), as well as on the final visualization type (static, dynamic, interactive). This additional content can be used to visualise content which cannot be successfully visualised through an interactive 3D web model, e.g. renderings of highly detailed 3D models or visualisation of full point cloud datasets.

STATIC IMAGES

- 3D renderings of visually enriched models from several perspectives
- Elevations, plans and sections of point cloud data
- Images highlighting specific features of the cultural object

ANIMATION

- Turn table video
- Flythrough animation and video tours
- Structural animation highlighting different components of an artefact or monument and their interrelationship
- Temporal animation highlighting the chronological change of a structure, e.g. animation from present day ruin back to reconstruction model

INTERACTIVE IMAGES

- Panoramas
- VR Objects

COMPLEMENTARY 2D MEDIA DERIVED FROM THE 3D MODEL. ABBEY OF SAINT-MICHEL DE CUXA (CNRS-MAP)

3D PUBLISHING METHODOLOGY

This section of the guidelines outlines the different methodologies and technical solutions for the optimal delivery and display of rich and complex 3D assets online. When evaluating publication formats the selection needs to consider the wide range in potential users from the general public to the researcher. Online publishing choice should be based upon the following criteria:

- serve a wide variety of needs and users
- maximise the 3D user experience
- focus on accessibility providing an easy and intuitive experience for the unequipped user
- maximise the availability of the 3D content on as many browser platforms as possible (desktop and mobile)
- focus on single release of models which can operate on as many platforms and operating systems to facilitate efficient & sustainable production
- avoid users having to install additional software or plugins
- support the concept of resource exploration (e.g. integrated URLs)

Creators of 3D content will also need to consider if the online 3D models require file format conversion and optimisation procedures to enable their use online, to ensure a responsive and pleasant user experience. It is important to evaluate which is the most optimal approach, taking into account the potential effort required for file format conversions and optimisation procedures.

ONLINE PUBLICATION TECHNOLOGIES

A range of suitable solutions exist for the creation and publication of online 3D content, each with their benefits, limitations and applicability to cultural heritage.

3D MODEL	OBJECTS		COMPLEX BUILDINGS		SITES	
Complexity	**Low**	**High**	**Low**	**High**	**Low**	**High**
3D PDF	Yes					
HTML5/WebGL	Yes	Optimised model Nexus/ point cloud		Optimised model Point cloud		Optimised model Point cloud
X3D	Yes	Optimised model	Yes	Optimised model	Yes	Optimised model
Unity3D/UnReal			Yes	Optimised model		Optimised model
Pseudo-3D	Special cases (glass etc)	Yes		Yes		Yes

3D PDF

The 3D PDF offers the ability to integrate 3D models and annotations within a PDF document. The 3D PDF format natively supports the Universal 3D (U3D) and Product Representation Compact (PRC) 3D file formats. The 3D PDF format was previously recommended within two EU projects: CARARE & Linked Heritage Project.

ADVANTAGES INCLUDE:

- Predefined views can be embedded for the user, e.g. inside different rooms of a building
- Majority of users already have a PDF viewer such as Acrobat Reader installed on their computer
- Models are relatively easy to use
- Models are 100% self-contained - allows the use of a single Uniform Resource Identifier (URI) in order to define a complete 3D model
- The user is provided with limited tools to measure and section
- Suitable for desktop browsing direct visualisation of 3D PDF on desktop computers
- Textures can use the jpeg compression feature of 3D PDF to reduce file sizes
- Additional media content such as text, video, images can be embedded within the PDF

DISADVANTAGES INCLUDE:

- When opening a 3D PDF documents through a browser, which is often the case with hyperlinked documents, different display behaviours occur, depending on the browser as 3D PDF not supported in web browser itself due to security issue
- PDF must be viewed within Acrobat Reader- not obvious for non technical user
- Models are not normally highly optimized for online use resulting in long download times and inability to work on slower machines
- The use of 3D PDF on mobile devices requires the use of an App with limited functionality

The main authoring platform is Acrobat Pro, which, in combination with the 3D PDF Converter plug-in (only on Windows) and additional software allows importing 3D models in a large number of file formats, and additional media. 3D PDF files can be created in Acrobat Pro without the Tetra4D Converter plug-in if one is capable of translating the 3D models into U3D file format (for example through MeshLab), this workflow is available on both Mac and Windows.

3D PDF MODEL OF A STONE HIGH-RELIEF DEPICTING A HUNTER WITH A HARE WHICH IS ACCOMPANIED BY A MASTIFF (UNIVERSIDAD DE JAÉN)

HTML5/WEBGL SOLUTIONS

With the advent of HTML5 and its associated WebGL JavaScript API the interactive rendering of 3D visualisation can be achieved in a web browser without installing additional software or plugins by using the canvas element of HTML5. WebGL was utilised within the 3D-COFORM project as the method of choice for online 3D delivery. Most new HTML5/WebGL solutions use a cloud solution, in which the 3D models reside on servers of the company providing the visualisation software, but the final model can be embedded on a normal HTML web page using canvas and iframes.

ADVANTAGES INCLUDE:

- Supported automatically by many HTML5 desktop browsers (Chrome, Firefox, Opera, Internet Explorer), however, Safari browsers requires users to enable it
- Increasing mobile support (Blackberry's mobile browser fully supporting WebGL content and partial support on the Android Chrome browser)
- Allows direct access to the graphics processing unit (GPU) on the hardware display card present in the computer
- As WebGL utilises HTML5 the minimum requirements of creating a WebGL application is a text editor and a web browser
- Can be used for the visualisation of point cloud data

DISADVANTAGES INCLUDE:

- iOS does not currently support WebGL but from iOS 8 this will be implemented and is currently being beta tested
- Security concerns exist as WebGL utilises the GPU and can give a malicious program the ability to force the host computer system to execute harmful code
- It is not supported by older graphics cards
- There is currently a lack of development environments

3D MODEL TYPE	SOFTWARE	COMMENTS
Object/artefact	**P3D**	• Online storage: 100Mb (Free) 3Gb (paid) • Visualisations can use alpha, bump, glossy, AO, glow, detail and spherical reflection maps in paid version • Only .obj format supported • Viewport shading option available
	Big Object Base (BOB) Publish	• Only paid service • Support for large meshes which exceed WebGL triangle count • Flash alternative for non WebGL browsers • Option of viewer App for mobile devices
	3DHOP	• 3D streaming capability for multi-resolution models • Nexus format ability to compression and streaming 3D content that refines gradually depending upon the zoom level of the user • Limited to colour per-vertex data • User has the ability to dynamically adjust the lighting position • Efficient presentation of 3d scan data as simplification & optimisation processing normally required to view detailed model s is not required
	SketchFab	• Offers automated pseudo3D solutions for browsers where WebGL is not available • Free and ability to import 28 different file formats • Visualisations can use standard diffuse, specular and shininess parameters, and light maps • Annotation of objects available
Scene/building	**CopperCube 3D**	• Suitable for complex scenes requiring walkthrough and guided tours • Comprehensive built in features for to interact with building or site (collision detection, walking on surface • Light mapping and particle effects supported • Content available through mobile apps • Character animation available • Supports import of 22 file formats • Supports immersive environment with Occulus Rift Windows and Mac availability
Point cloud	**Potree**	• Ability to load incrementally LOD point clod data • User has ability to adjust LOD, and point size within viewer point cloud dataset must be processed using a free conversion tool • Open source solutuion

A RANGE OF APPLICATIONS EXIST FOR WEBGL-BASED 3D TYPICALLY STORING THE 3D DATA IN THE CLOUD BASED SERVERS AND PROVIDING VISUALISATION OF THE 3D CONTENT.

THOLOS IN DELPHI, GREECE 3D POINT CLOUD MODEL VIEWED ON-LINE USING THE POTREE WEBGL VIEWER (CNRS-MAP)

RETOPOLOGISED LIGHT WEIGHT MODEL OF THE MARKET CROSS, GLENDALOUGH VIEWED IN THE SKETCHFAB ONLINE WEBGL VIEWER (DISCOVERY PROGRAMME)

CAPITAL IN NEXUS ON-LINE VIEWER FORMAT FROM THE CEFALU CLOISTER IN SICILY, ITALY (ISTI-CNR)

X3D

X3D is the technological successor and extension to VRML which is recognised by the International Organisation for Standardization (ISO). Currently X3D provides native authoring and use of declarative XML-based X3D scenes which can be viewed within a HTML5 web browser, and provides *Extensible Markup Language* (XML) capabilities within 3D to integrate with other WWW technologies.

ADVANTAGES INCLUDE:

- provides enhanced 3D visualisation capabilities - multi-stage and multi texture rendering, lightmap shaders, real time reflection, Non-uniform rational basis splines (NURBS)
- Utilising JavaScript library X3DOM, X3D scenes become part of the HTML DOM
- X3DOM can be used into of WebGL therefore it can be run directly in the browser, without any plug-in
- 3D models can utilise the GNU gzip compression to reduce their files size

DISADVANTAGES INCLUDE:

- 3D model is constructed from multiple files therefore files structure is not contained and cannot be referenced via a single URI
- Compatibility issues exist as 3D model with the specific viewer multiple files e.g. texture maps required to construct scene

The X3D format provides a wide range of authoring tools for the production of X3D models or with X3D export functions including open source (Blender and Meshlab) and paid solutions (AC3D).

THE 3D MODEL OF THE METOPE SELE HERAON DISPLAYED WITHIN AN X3D VIEWER (FONDAZIONE BRUNO KESSLER)

UNITY - SERIOUS GAMES SOLUTIONS

Technology solutions developed for the provision of online gaming activities can be utilised for the visualisation and exploration of cultural heritage objects. Unity is one such game platform which can provide a solution to providing rich 3D environments for users.

ADVANTAGES INCLUDE:

- Advanced visualization features including: real-time global illumination, reflection probes, physically based shading, ability to embed audio, complex animation
- Can be utilised on all major desktop platforms (Windows, MacOS, Linux) and all major mobile platforms (Android, iOS, Windows Phone, Blackberry)
- Collision detection, the notion of ground surfaces and interactive objects e.g. doors
- Provides users with exploratory and non-linear 3D space
- Gaming environment is easy to use for non-technical users

- Very suitable for the provision of interactive models of heritage spaces (e.g. buildings and archaeological sites)
- Web publishing is free
- Large community of user providing additional tools and plug-in

DISADVANTAGES INCLUDE:

- Currently Unity v.4 requires a plug-in to be installed on the user's machine, however, from the release of Unity v.5 online publishing within HTML5 capabilities will be available
- Cost of software required to author 3D scenes if Pro functions required

Other game engine platforms adopted for serious gaming such as the Unreal Development Kit (UDK) are available; however, most require the installation of an additional plug-in.

UNITY3D TEST ON THE 3D VIRTUAL RECONSTRUCTION OF THE ENAME ABBEY IN 1300 (VISDIM)

PSEUDO3D (OBJECTVR) SOLUTIONS

Pseudo3D provides the user with a near to 3D experience by allowing the user to navigate interactively through a series of images taken at different orientations which mimics real 3D visualisation. Psuedo3D can provide solutions to view 360 panoramas or to provide an orbital view of an object (ObjectVR). Pseudo3D solution is a valuable tool for online display where:

- Complex 3D models cannot be rendered online in real time e.g. large point cloud models
- 3D digitisation of an object is not possible, but photography with the resulting images combined allow the user a pseudo3D experience
- It provides a solution for users that have hardware with very limited graphical capabilities
- Particularly suitable for the display of complex 3D artefact models

Several software solutions are available to construct Object VR visualisations (Flashificator, BoxshotVR, Object2VR, Krpano) all which can produce content via HTML5 (use of QuicktimeVR requires a plugin and is therefore not suggested). Many of these tools also offer the user the ability zoom into the object and closely inspect the models if high resolution images are used to create the ObjectVR. However, one limitation to this solution is its ability to confine the user to visualise the object through a predefined paths.

TWO IMAGES FROM AN OBJECTVR VISUALISATION OF THE ABBEY OF ENAME IN 1665 (BY VISDIM)

REMOTE RENDERING

Interactive remote rendering uses the combination of an interactive low resolution 3D model (visualised through WebGL) with rendering the corresponding high resolution 3D model on a remote server and sending just the rendered image to replace the low resolution WebGL visualisation. An example of this application is the Venus 3D model publishing system (CCRM Lab).

ADVANTAGES INCLUDE:

- the 3D model does not need to be transferred over the internet and reside on the user's computer, only the jpeg image is transferred
- user has the ability to dynamically alter lighting position and inspect detailed 3D models

DISADVANTAGES TO THIS METHOD INCLUDE:

- centralised hosting of the service would incur ongoing costs
- the lag time the experienced whilst waiting for the render to occur can be quite off putting for the user and is dependent upon the user's internet speed

IPR CONSIDERATIONS FOR ONLINE PUBLISHING

An additional consideration for online publication is the IPR implications of the 3D models. Although the ability to potentially "steal" 3D models & visualisation should not be considered as a major threat, several factors should be considered depending upon the publication method including:

- 3D files which reside on a server and can be downloaded for visualisation e.g. 3D PDF could potentially be reuse and altered by the user. Password protection is available to encrypt the data, although there is the potential to bypass this and extract the 3D model
- Where 3D models are offered to the user through an embedded HTML5 service and the 3D data is hosted by a third party (e.g. SketchFab) care must be taken to inspect their rights on the uploaded data

METADATA

Running in parallel to the 3D capture, modelling and publication activities, the creation of metadata is essential to the success of the processing pipeline. The metadata created within the pipeline provides key information and context data to five key areas:

1. It describes in detail the artefact or monument which is being modelled in 3D and its provenance
2. It describes in detail the digital representation of the artefact or monument and its online location
3. It provides technical information and quality insurance on the processes and methods utilised in the digitisation and modelling of heritage objects
4. It provides information on the access, licensing and reuse of the created 3D models and any associated digital content
5. It enables the search, discovery and reuse of content through the mapping of metadata to aggregators e.g. Europeana Data Model (EDM)

CARARE 2.0 METADATA SCHEMA

To construct a comprehensive metadata record for digital content created through the pipeline, which adheres to the five key areas described above, the CARARE 2.0 Metadata scheme was selected. The CARARE metadata schema was developed during this EU co-funded three-year project which addressed the issue to make digital content, including information about archaeological monuments, artefacts, architecture, landscapes, available to Europeana's users. The CARARE schema works like an intermediate schema between existing European standards and the EDM by:

- ensuring interoperability between the native metadata held by heritage organisations and Europeana
- creating a metadata schema able to map the existing original metadata into a common output schema
- supporting the full range of descriptive information about monuments, buildings, landscape areas and their representations

The CARARE schema is focussed on a heritage asset and its relations to digital resources, activities and to collection information. The fundamental elements within its structure are:

CARARE Wrap - the CARARE start element. It wraps the Heritage Asset with the other information resources

Heritage asset Identification (HA) – the descriptive information and metadata about the monument, historic building or artefact. The ability to create relations between heritage asset records allows the relationships between individual monuments that form parts of a larger complex to be expressed

Digital resource (DR) – these are digital objects (3D models, images, videos) which are representations of the heritage asset and are provided to the services such as Europeana for reuse

Activity (A) - these are events that the heritage asset has taken part in, in this case this is used to record the data capture and 3D modelling activities (paradata) which are utilised to create the 3D content

Collection (C) – this is a collection level description of the data being provided to the service environment (Europeana)

GRAPHICAL EXAMPLE OF THE RELATIONS AMONG THE DIFFERENT THEMES (HERITAGE ASSET, DIGITAL RESOURCES AND ACTIVITIES) OF CARARE 2.0

OBJECT DIGITAL ASSETS RELATIONSHIP WITHIN CARARE

The creation of metadata for cultural heritage objects and their associated digital heritage assets, (3D models, images and videos) should adhere to the following approach to capture the relationship between digital replicas and their original monuments or artefacts.

THE PARTNER HAS ONE OR MULTIPLE 3D DIGITAL MODELS AS REPLICAS OF ONE PHYSICAL OBJECT

DIAGRAM ILLUSTRATING APPROACH TO METADATA CREATION FOR MULTIPLE DERIVATIVES FROM A SINGLE CULTURAL HERITAGE OBJECT

PARADATA

A specific form of metadata which is recommended within the 3D documentation process is the paradata. Paradata is information and data which describes the process by which the 3D data was collected, processed and modelled and can act as a quality control audit for the data. Examples of paradata include:

- type of 3D data collection technique (image based or range based)
- type of equipment (model of the camera, lenses used, triangulation or TOF laser scanner, etc.)
- which software applications where used to process the data

The recording of paradata can be achieved both automatically and systematically during the survey process. Where possible, paradata data created by capture devices, e.g. exif information from cameras should be utilised. For all additional paradata information the use of standardised paradata recording sheets should be utilised to ensure systematic recording of techniques, equipment and processes. An example paradata recording sheet created as part of the 3D-ICONS project is available online for reuse at the project website. In terms of inclusion of the paradata within the overall metadata schema, all paradata created can be mapped into the Activity component of the CARARE metadata schema.

STANDARDISED VOCABULARY

Where possible standardised vocabularies and their associated persistent uniform resource identifier (URI) should be utilised within the metadata to develop and promote the use of semantic tools enabling interoperability, integration and the migration of the digital resources in the Linked open data Format Standardised vocabulary.

CARARE THEME	RELEVANT RESOURCES
CARARE Theme	FOAF (http://www.foaf-project.org/)
Actor	DBpedia (http://dbpedia.org/About)
Concepts	Gemet Thesaurus (http://www.eionet.europa.eu/gemet) Getty Thesaurus (http://www.getty.edu/research/tools/vocabularies/aat/) HEREIN Thesaurus (http://thesaurus.european-heritage.net/herein/thesaurus/) ICCD/Cultura Italia Portal (http://www.culturaitalia.it/) Linked Data Vocabularies for CH (http://www.heritagedata.org/) GeoNames (http://www.geonames.org/)
Spatial Data	Getty Thesaurus of Geographic Names (http://www.getty.edu/research/tools/vocabularies/tgn/) Ancient Place names - Pleiades (http://pleiades.stoa.org/)

TABLE SUMMARISING AVAILABLE RECOGNISED ONTOLOGIES & THESAURI WHICH CAN BE USED IN METADATA CREATION FOR CULTURAL HERITAGE OBJECTS

RESOURCES FOR METADATA CREATION

The actual process of metadata creation can be achieved using two different application paths:

ILLUSTRATION OF THE DIFFERENT STRATEGIES IN THE IMPLEMENTATION OF METADATA CREATION

STRATEGY 1: METADATA CREATION TOOL

For those institutions and organisation which have no previous descriptive data relating to their collections to map, or have little experience in the production of XML metadata records the creation of metadata can be achieved utilising the online 3D-ICONS Metadata creation tool. Available online (http://orpheus.ceti.gr/3d_icons), the tool provides the user with the ability to define separate building blocks of the CARARE metadata data schema:

- **Organization** – The organisation(s) with the responsibility for the 3D digital object assets
- **Collection** – A description of the overall 3D collection made available
- **Actor** – The person/people who have carried out the data collection and processing tasks, e.g. geo-surveyor
- **Activity** – Descriptive detail of the digitisation and modelling activities utilised, e.g. terrestrial laser scanning
- **Spatial data** – Geographical location of the cultural heritage object
- **Temporal data** – chronological period or date associated with the cultural heritage object
- **Digital Resources** – Description of the digital representation file, e.g. jpeg image

DEFINING A HERITAGE ASSET WITHIN THE METADATA CREATION TOOL

VIEW OF ASSOCIATED DIGITAL ASSETS WITHIN THE METADATA CREATION TOOL

STRATEGY 2: MINT2 MAPPING TOOL

For those organisations which have their metadata already created and contained within their own formalised cataloguing management software, e.g. museum collections databases, this can be reused to form the main component of the CARARE metadata record. To achieve this, the MINT 2 metadata services tool can be employed.

MINT 2 services comprise of a web based platform that is designed and developed to facilitate aggregation initiatives for cultural heritage content and metadata in Europe. The platform offers an organisation a management system that allows the operation of different aggregation schemes (thematic or cross-domain, international, national or regional) and corresponding access rights. Registered organizations can upload (http, ftp, OAI-PMH) their metadata records in xml or csv format in order to manage, aggregate and publish their collections.

The CARARE metadata model serves as the aggregation schema to which the ingested data is mapped. Users can define their metadata crosswalks from their own schema to CARARE with the help of a visual mappings editor utilising a simple drag-and-drop function which creates the mappings. The MINT tool supports string manipulation functions for input elements in order to perform 1-n and m- mappings between the two models. Additionally, structural element mappings are allowed, as well as constant or controlled value (target schema enumerations) assignment, conditional mappings (with a complex condition editor) and value mappings between input and target value lists. Mappings can be applied to ingested records, edited, downloaded and shared as templates between users of the platform.

SCREEN SHOT OF THE MAPPING PROCEDURE WITHIN MINT 2

Once mapped the MINT tool preview interface enable the user to visualise the steps of the aggregation including the current input xml record, the XSLT of their mappings, the transformed record in the target schema, subsequent transformations from the target schema to other models of interest (e.g. Europeana's metadata schema), and available html renderings of each xml record.

VISUALIZATION OF THE MAPPED RECORD METADATA RECORD IN MINT 2

RELATING METADATA TO EUROPEANA – MORE 2.0

Once the metadata record packages have been created by either the online metadata tool or the MINT 2 service these are transformed into the EDM, and delivered to Europeana using the Monument Repository (MoRe2) services. The MoRe 2 repository aggregator tool also enables ingested metadata records to be validated against specific quality control criteria, e.g. correct spatial coordinates are utilised for the spatial location.

The MoRe 2 system also provides users with summary statistics of their metadata records including the number of Heritage Assets ingested and the number and type of digital media objects referenced, e.g. images, 3D models. Once validated and ingested metadata data records can then be easily published to Europeana with the click of a button.

SCREEN CAPTURE OF THE MORE 2.0 TOOL DISPLAYING INGESTED METADATA PACKAGES

LICENSING & IPR CONSIDERATIONS

In order for the effective sharing and reuse of 3D content of heritage objects a common framework is required to establish best practice in the management and licensing of 3D models and any associated digital objects (video, metadata & images). Understandably many institutions have the concern that providing access to 3D content could potentially erode their commercial rights to the data.
The standardised IPR scheme presented:

- Identifies the key data and relationships which require management
- Provides robust licences to retain commercial rights to the data whilst enabling reuse for educational and research activities
- Collates suitable metadata with an appropriate (Creative Commons CC0) licensing structure for submission to Europeana
- Examines the key copyright challenges faced by all parties involved in the process of capturing, processing, developing and presenting digital content

IPR & THE 3D PIPELINE

The creative processes and activities involved in this 3D pipeline results in the generation of Intellectual Property Rights (IPR) at many junctions. The development of a suitable IPR model is relevant at all stages of the pipeline, from the earlier phases which are dominated by controlled access rights, to the later phases where substantial effort is invested in the modelling of captured 3D data to produce rich and effective 3D heritage content. This is important in terms of recognising that while the content providers may control access, it is the later processes that have the highest costs and greatest IPR.

ILLUSTRATION OF THE OBJECT ACTIVITY CHAIN IDENTIFYING THE RANGE OF PEOPLE AND ORGANISATIONS INVOLVED IN CREATING 3D CONTENT FOR CULTURAL

The IPR scheme proposed here is integrated into all the activities of the3D modelling pipeline from initial data capture to the delivery of 3D heritage content online. Within the pipeline several key actors and organisations are defined:

- **Monument/artefact Manager** – organisation who are the custodians or owners of the heritage object, e.g. museum
- **Imaging Partner** – company or institution which carries out the primary 3D data capture of the heritage object
- **3D Development Partner** - company or institution which executes the 3D data modelling of the heritage object for delivery online
- **Distribution Partner** – organisation which hosts 3D content for public use
- **Commercialisation Partner** – company which wishes to establish a potential revenue path for 3D data

Within the processing pipeline there are several milestones where IPR agreements need to be applied.

ACCESS AGREEMENT

At the start of the pipeline , where Imaging Partners capture 3D data of a monument or artefact in the ownership or management of a third party (e.g. National Heritage organisation) it is good practice to establish an Access agreement. This agreement outlines both the arrangements in place to physically access the site/museum to capture the data, and what level of control each party has over the initial survey data captured. Depending upon who is funding the work two standard agreements are possible:

- Full or co-funding for capture provided by Imaging Partner - non-exclusive licenses for both parties to make use of the primary data with the IPR resting with the Imaging Partners
- Full funding provided by Heritage Organisation - assignation of the IPR by the Imaging Partners to the heritage body

It is also important to clearly state the IPR on any subsequent 3D content derived from the original captured data as these are new and distinct data sets and often require significant amounts of effort to produce the final deliverable 3D model.

DERIVATIVES AGREEMENTS

Depending upon the attitude of the Imaging Partner to data sharing, the original 3D capture data (e.g. high quality point cloud data) will not normally be publicly accessible. However when new products are derived by a third party a Business-2-Business (B2B) derivative agreement will be required. For organisations where the data capture and 3D modelling is carried out within the same institution no additional derivative agreement is required.

METADATA AGREEMENTS

Where metadata and paradata is provided by 3D content creators to third parties such as Europeana for the purpose of increasing the visibility and reuse of the 3D models a Creative Commons (CC0) License is usually adopted. The metadata agreement will not interfere with any subsequent commercialisation of content by the rights holder.

PUBLIC USE AGREEMENTS

The 3D models and other associated derived products such as videos and images will normally be made widely available to the public using a more restrictive arrangement than the metadata agreement to retain control over potential commercial and inappropriate future reuse. This will be dependent upon the policy of the 3D content creator organisation and can range from the restrictive (paid access - no reuse) to the liberal (CC0) but is likely that organisation would like to retain some potential commercial value in their models. It is recommended that organisations at least apply the Creative Commons Attribution-Non-Commercial-No-Derivatives (CC-BY-NC-ND) license to their model which allows for the redistribution and non-commercial reuses, as long as the 3D content is unchanged and credits the creator organisation. The full range of potential rights statements available through European can be found at http://pro.europeana.eu/web/guest/available-rights-statements.

COMMERCIAL AGREEMENTS

Final 3D models, additional content (videos and rendered images) and supplementary data created within the 3D pipeline process have the potential to be commercialised. Licensing models to commercial image libraries or directly to end users can help fund the creation of higher quality models and may well be in the interest of all parties – as once created resources may be used commercially and non-commercially. These agreements are a critical part of stimulating an added value chain so that original survey work can reach its full potential.

VISUALISATION OF THE DIFFERENT AGREEMENTS AND LICENSE STRUCTURES WHICH CAN BE UTILISED DURING THE CAPTURE, MODELLING AND REUSE OF 3D CULTURAL HERITAGE MODELSIN CREATING 3D CONTENT FOR CULTURAL HERITAGE

CREATIVE COMMONS KEY FACTS

Founded in 2001 and thanks to the proliferation of the internet and web sites like Wikipedia, Creative Commons has become one of the most recognised licensing structures available. As this also forms the IP structure for Europeana.

Enables the sharing and use of creativity and knowledge through free, public, and standardized infrastructures and tools that creates a balance between the reality of the Internet and the reality of copyright laws.

Creative Commons licenses require licensees to get permission to do any of the things with a work that the law reserves exclusively to a licensor and that the license does not expressly allow.

Creative Commons Licensees must credit the licensor, keep copyright notices intact on all copies of the work, and link to the license from copies of the work.

CC Licenses are available from a fully open license where users can copy, modify, distribute and perform the work, even for commercial purposes, all without asking permission (C00) to the restrictive CC BY-NC-ND where others can download your works and share them with others as long as they credit you, but they can't change them in any way or use them commercially.

INCREASED REUSE RESTRICTION

PUBLIC DOMAIN - CC0

ATTRIBUTION - CC BY 3.0

ATTRIBUTION-SHAREALIKE - CC BY-SA 3.0

ATTRIBUTION-NODERIVS - CC BY-ND

ATTRIBUTION-NONCOMMERCIAL - CC BY-NC

ATTRIBUTION-NONCOMMERCIAL-SHAREALIKE - CC BY-NC-SA

ATTRIBUTION-NONCOMMERCIAL-NODERIVS - CC BY-NC-ND

3D-ICONS CASE STUDIES

The case studies presented here are just a representative selection from over 1,000 3D models of cultural heritage objects produced by the project partners during the course of the 3D-ICONS project. Each project partner has provided two case studies which have been grouped within two broad ranges of cultural heritage object - monuments and buildings, and artefacts and architectural detail. In order to summaries each case study the relevant information has been presented utilising the following guidelines:

LOCATION
Place name and map location of the heritage object.

INSTITUTE
The organisation who contributed the case study.

DESCRIPTION
A summary of the cultural heritage object and its heritage value.

CAPTURE
The methodology utilised to digitise the CH object in 3D.

EQUIPMENT
What instruments where utilised in the data capture?

MODELLING SOFTWARE
What software applications where utilised in the processing and delivery pipeline.

PROCESSING PIPELINE
A summary of the relevant technical steps required to go from 3D capture to online 3D delivery of the cultural heritage object.

ONLINE DELIVERY
How was the 3D model of the cultural heritage object being delivered online and why (URL denotes the online location for access to the 3D model of the cultural heritage object)?

MODEL USE
How is it envisaged that the 3D data will be used?

LICENSE
What IPR licensing has been employed for use and reuse of the 3D data?

MONUMENTS

01 ABBADIA CASTLE / HENDAYE, FRANCE

02 AUGUSTEUM (HERCULANEUM) / HERCULANEUM, CAMPANIA, ITALY

03 BADIA CAMALDOLESE DI VOLTERRA / VOLTERRA, TUSCANY, ITALY

04 THE CENACLE COMPLEX / JERUSALEM, ISRAEL

05 CHARTREUSE OF PAVIA / PAVIA, LOMBARDY, ITALY

06 CHURCH OF THE HOLY APOSTLES / THESSALONIKI, CRETE, GREECE

07 CLOISTER OF THE ABBEY OF SAINT MICHEL DE CUXA / SAINT MICHEL THE CUXA, FRANCE

08 ENAME ARCHAEOLOGICAL SITE / ENAME, BELGIUM

09 HOUSE 07, SKARA BRAE / SKARA BRAE, ORKNEY, SCOTLAND, UK

10 KUTUKLU BABA TEKKESI / XANTHI, GREECE

11 MAUSOLEUM OF ROMULUS / ROME, ITALY

12 SAINT LAURENTIUS CHURCH / ENAME, BELGIUM

13 SANCTUARY OF THE IBERIAN OPPIDUM OF PUENTE TABLAS / JAÉN, SPAIN

14 SKARA BRAE / SKARA BRAE, ORKNEY, SCOTLAND, UK

15 ST KEVIN'S CHURCH / GLENDALOUGH, WICKLOW, IRELAND

16 TOMB OF THE RELIEFS / CERVETERI, ROME, ITALY

ARCHITECTURAL FEATURE

01 CAPITAL OF THE ABBEY NOTRE DAME DE LA SAUVE MAJEURE / LA SAUVE, BORDEAUX, FRANCE

02 DAVID DI DONATELLO / MUSEO NAZIONALE DEL BARGELLO, FLORENCE, ITALY

03 GRIPHOMAQUIA. SCULPTURE OF THE GROUP OF CERRILLO BLANCO / PORCUNA, JAÉN, SPAIN

04 LADISALU HUNYADI'S MARBLE SARCOPHAGUS / SAINT MICHAEL ROMANO-CATHOLIC CATHEDRAL, ALBA IULIA. ROMANIA

05 THE MARKET CROSS / GLENDALOUGH, WICKLOW, IRELAND

06 SANTA CRISTINA SACRED WELL / SARDINIA, ITALY

07 "SUICIDE OF AIACE" METOPE / PAESTUM, CAMPANIA, ITALY

ARTIFACT

08 CHRYSIPPUS HEAD / TEMPLUM PACIS, ROME, ITALY

09 EL ARGAR POTTERY / ROYAL MUSEUMS OF ART & HISTORY, BRUSSELS, BELGIUM

10 EL ARGAR SKULL / ROYAL MUSEUMS OF ART & HISTORY, BRUSSELS, BELGIUM

11 FURNITURES OF THE PETIT TRIANON 3D / VERSAILLES, FRANCE

12 THE GODDESS OF SULTANA NEOLITHIC IDOL / MUZEUL NAȚIONAL DE ISTORIE A ROMÂNIE, BUCHAREST, ROMANIA

NAME OF MONUMENT

ABBADIA CASTLE

LOCATION
HENDAYE, FRANCE

INSTITUTE
ARCHEOTRANSFERT
HTTP://ARCHEOTRANSFERT.CNRS.FR

OBLIQUE AERIAL IMAGE ABBADIA CASTLE

DESCRIPTION
Chateau d'Abbadie is a chateau in Hendaye, Pyrénées-Atlantiques, France. Built between 1864 and 1879, it was designed in the neo-Gothic style by Viollet-le-Duc and incorporated many enigmatic features characteristic of its owner, the explorer Antoine Thomson d'Abbadie.

EQUIPMENT
Nikon D800E

CAPTURE
Image-Based - Traditional Photogrammetry - possibility of aerial photography with drone. Better implementation of the digitization process.

MODELING SOFTWARE
Synaps and Geomagic

UAV HEXACOPTER USED TO CAPTURE SFM IMAGERY OF THE CASTLE

MODEL USE
Promotion of the cultural heritage.

PROCESSING PIPELINE
Treatment of the photographies (light, contrast resolution etc), point cloud processing, point cloud cleaning, meshing.

ONLINE DELIVERY
WebGL - Cross-browser and cross-platform compatibility - Tight integration with HTML content, including layered compositing, interaction with other HTML elements, and use of the standard HTML event handling mechanisms - Hardware-accelerated 3D graphics for the browser environment - A scripting environment that makes it easy to prototype 3D graphics.

http://archeogrid.ubordeaux3.fr/3DIcons/3diconsview3d.php?id=12

COLOURISED DENSE POINTCLOUD MODEL OF ADDADIA CASTLE

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NAME OF MONUMENT

AUGUSTEUM (HERCULANEUM)

LOCATION
HERCULANEUM, CAMPANIA, ITALY

INSTITUTE
UNIVERSITÀ DEGLI STUDI DI NAPOLI "L'ORIENTALE", NAPLES, ITALY
WWW.UNIOR.IT/ATENEO/231/1/CISA-CENTRO-INTERDIPARTIMENTALE-DI-SERVIZI-DI-ARCHEOLOGIA.HTML

3D DATA-CAPTURE BY SFM

THE ENTRANCE OF THE AUGUSTEUM

DESCRIPTION
The Augusteum at Herculaneum was probably a building dedicated to the Imperial cult. Although still completely buried save for part of its entrance porch, this huge building was extensively explored and thoroughly looted by its early excavators. Many frescos and statues removed from the Augustum were carried in the Archaeological Museum of Naples. Augusteum was brought to the light through tunnel excavated in the volcanic rock. Currently the Monument is not accessible.

CAPTURE
Image-Based - Structure from Motion (SfM)
Digitised plans/records - All of the artefacts, which once decorated the Augusteum are now held in the National Archaeological Museum of Naples. We rebuilt the Augusteum virtually restoring the monument with all statutes and frescos.

EQUIPMENT
NIKON D90 + Trimble Total Station Trimble

MODELING SOFTWARE
Photoscan, Geomagic, 3DStudioMax

LOW-RESOLUTION MODEL OF THE AUGUSTEUM RECONSTRUCTED FROM OLD MAPS AND EXCAVATION PLANS

LOW-RESOLUTION MODEL OF THE AUGUSTEUM RECONSTRUCTED FROM OLD MAPS AND EXCAVATION PLANS

PROCESSING PIPELINE
The 3D model of the monument was generated using CAD from historical maps and building footprints taken during the excavation. The statues, actually in the Archaeological Museum of Naples, were acquired in 3D by SFM and then reallocated in their original position. Also the digitized images of frescos were reallocated. The entrance porch, the only part actually visible, was acquired by SFM and joined to the reconstructed model.

ONLINE DELIVERY
3D PDF - we do not have the permission to publish an high resolution model of the monument.

http://www.archeozone.it/3DIcons/basilica%20ercolano_3d%20fronte.avi

MODEL USE
The monument is not accessible and not visible therefore this is the only way to provide access to a rebuilt model of the Augusteum including artefacts and decoration held in the Archaeological Museum of Naples.

DENSE POINT MESH MODEL OF THE ENTRANCE OF THE AUGUSTEUMMODEL OF THE CAPITAL GENERATED THROUGH SFM

© LICENCE / TO BE CONFIRMED

NAME OF MONUMENT

BADIA CAMALDOLESE DI VOLTERRA

LOCATION
VOLTERRA, TUSCANY, ITALY

INSTITUTE
ISTI-CNR.
WWW.ISTI.CNR.IT

THE SCANNING OF THE APSE

DESCRIPTION

The place is an old monastery in the outskirts of the town of Volterra, dating back to the 10th-11th century. The structure has been expanded and modified many times over the centuries and it was severely damaged by an earthquake in the 19th century, and shortly later abandoned. The whole building is undergoing a process of slow recovering and restoration, with the aim of potentially reusing the building. The scanning campaign covered the remains of the church, in order to produce accurate and effective documentation for possible interventions, and to help better understanding the reasons of the collapse, through the study of the available historical sources, chronicles and a virtual reconstruction of the church in its original state.

A RENDERING OF THE VIRTUAL RECONSTRUCTION

CAPTURE

Terrestrial Laser Scanning - Phase based
For the size of the object we required detail and rapid digitization.

EQUIPMENT

FARO Photon 120

MODELING SOFTWARE

MeshLab for 3D scanning data processing and model creation, AutoCAD for the virtual reconstruction of the original state

THE "CLOSED" 3D MODEL, USED FOR 3D PRINTING

PROCESSING PIPELINE

Field scanning - data exporting: single scans to point-clouds with normals - pointclouds cleaning (trees, unwanted areas, people, "ghost" points) - alignment of scans (markerless, using the geometric redundancy) - surface creation - model editing for 3D printing - creation of hi-res orthographic views for technical documentation - extraction of measurement / sections / notable points for virtual reconstruction of the original state - virtual reconstruction of the original state

ONLINE DELIVERY

3D HOP - Able to convey the hi-res model

http://artesalva.isti.cnr.it/en/virtual-visits-badia-volterra

MODEL USE

The model is not publicly available; it can be released for scientific purposes, by obtaining the permission from the superintendant. The 3D online browser is still not publicly accessible at present.

THE ALIGNED POINTCLOUD OF THE CHURCH

© LICENCE / PAID ACCESS - NO RE-USE

NAME OF MONUMENT

THE CENACLE COMPLEX

LOCATION
JERUSALEM, ISRAEL

INSTITUTE
THE CYPRUS INSTITUTE, STARC
WWW.CYI.AC.CY/STARC.HTML

LASER SCANNING THE INTERIOR OF KING DAVID'S TOMB COMPLEX

DESCRIPTION
The building complex is one of the most important monuments in Jerusalem, with a long and complex architectural history starting in the second century AD and continuing until the 14th century, hosting one of the earliest and better preserved examples of Crusader architecture of the "Kingdom of Jerusalem". The lower floor hosts the "Tomb of King David", among the largest cenotaphs ever built, while the upper floor is known as "The Room of the Last Supper" where, according to the Christian tradition, Jesus celebrated the Easter dinner and from where he was taken into custody prior his crucifixion.

CAPTURE
Image-Based - Structure from Motion (SfM)
Terrestrial Laser Scanning - Phase based
Cost efficient and easy to implement.

EQUIPMENT
Surphaser laser scanner, Menci ZScan

MODELING SOFTWARE
JRC, point cloud, AutoCAD, ZScan

SNAPSHOT FROM THE 3D MODEL OF THE CENACLE ROOM
- ARCHITECTONIC AND DECORATIVE ELEMENTS OF THE INTERIOR SPACE

THE CENACLE ROOM - DETAILS OF THE INTERIOR, SNAPSHOT OF THE 3D MESH

3D MODEL OF THE CENACLE COMPLEX FACADE - INTEGRATION OF STRUCTURE-FROM-MOTION MODEL WITH TERRESTRIAL LASER SCANNING

PROCESSING PIPELINE
scanning - alignment of scans - cleaning of data - simplification - alignment internal with external faces - mesh.

ONLINE DELIVERY
X3D - fast online rendering and does not require any specific software to visualise.

http://public.cyi.ac.cy/starcRepo/explore/objects

MODEL USE
Mostly informative

THE CENACLE COMPLEX - SNAPSHOT OF THE 3D MODEL SHOWING KING DAVID'S TOMB AREA AND THE ROOM OF THE LAST SUPPER; XRAY FILTER VIEW RE-COLOURED, GENERATED BY MESHLAB

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NAME OF MONUMENT

CHARTREUSE OF PAVIA

LOCATION
PAVIA, LOMBARDY, ITALY

INSTITUTE
POLITECNICO DI MILANO (POLIMI)
WWW.POLIMI.IT

DATA COLLECTION USING FARO FOCUS3D LASER SCANNER

DESCRIPTION

The Certosa di Pavia is one of the largest and Carthusian monasteries in Italy. The construction of the whole complex was started in 1396 and concluded in 1507. The location was strategically chosen midway between Milan and Pavia, the second city of the Duchy, where the Duke of Milan held his court. The long process for completing the buildings makes not only the building itself interesting, but also the diachronic reconstruction of the different phases of its evolution towards its final arrangement. The motivations behind the 3D digitization of this monument in the framework of the 3DICONS project are twofold: a) although the main church inside the monastery is well known, being one of the most visited monument in Lombardy, the buildings behind the church are largely misunderstood even if full of artistic and historical evidences.
This latter part has been scanned and 3D represented with a cloud of 3D points; b) most of the history of the place is "written in the stone", therefore reconstructing the historical evolution of the building through a set of 3D models based on actual 3D scans and historical documents, makes it easier to explain the monument genesis.

ELEVATION AND PERSPECTIVE VIEW OF POINT CLOUD

ONLINE 3D PDF MODEL

CAPTURE
Terrestrial Laser Scanning - Phase based. Most of the building is not easy to be reached; therefore we chose a 3D acquisition process capable to give metric results with no targets/signals added on the building surfaces, taking 3D information from a certain distance.

PROCESSING PIPELINE
Standard pointcloud processing

ONLINE DELIVERY
The model is too heavy for on-line delivery; therefore access in the form for requested DVD will be used

EQUIPMENT
Faro Focus 3D

MODEL USE
Virtual exploration/analysis

MODELING SOFTWARE
Leica Cyclone

HIGH RESOLUTION RENDER OF RECONSTRUCTED BUILDING

LICENCE
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NAME OF MONUMENT

CHURCH OF THE HOLY APOSTLES

LOCATION
THESSALONIKI, GREECE

INSTITUTE
ATHENA - CULTURAL & EDUCATIONAL TECHNOLOGY INSTITUTE (CETI)
HTTP://WWW.IPET.ATHENA-INNOVATION.GR

DIGITISATION OF CHURCH OF THE HOLY APOSTLES
- AERIAL DATA COLLECTION PHASE - CAMERA LOW ANGLE OBLIQUE SESSION

DESCRIPTION

The Church of the Holy Apostles is situated in the homonymous square in Thessaloniki, at the beginning of the modern Olympou Street. It lies south of the decumanus (Saint Demetrius Street), around 50 meters from the west city wall, near the Litea Gate, now a ruin today. Originally it was the katholikon (main church) of a sizeable monastery. Except for the church, little evidence remains today from the original complex, such as parts of the precinct, a gateway to the south of the katholikon and a large cistern to its northwest. Initially the monastery covered an area of more than 10.000 square meters. The dating of the church's construction (along with its bell tower) is part of an ongoing scientific debate. On the one hand, according to a new dendrochronological study the church was founded in no earlier than 1329. On the other hand, most scholars place the initial construction between 1310 and 1314. The designation of the church as Holy Apostles is of recent date and was said to be based on the existence of twelve vaults in the building. This popular association with the Apostles is documented in travellers' accounts as early as 1735. The building is in a good state of preservation with much of its original construction elements intact and visible. The church's original wall paintings and mosaics, concealed beneath a thick layer of plaster since the conversion into a mosque, were gradually uncovered and restored in various time periods, from the 1920s till 2004.

CAPTURE

Image Based Structure from Motion (SfM) & Dense Multi-View 3D Reconstruction Terrestrial Laser Scanning - Time of flight. This digitisation method allowed us to efficiently produce high quality 3D data within the time limits introduced by the project itself. SFM-Dense Multi-View 3D Reconstruction were the main methods being used for the generation of the digital 3D replica of the model.

EQUIPMENT

Samsung NX1000 Compact mirrorless DSLR 20MP 16mm, 20-50mm lenses Hexacopter (gimbal camera base,FPV,GPS lock) Optec Ilris 360D TOF laser scanner.

MODELING SOFTWARE

Photoscan, Meshlab, Blender

AERIAL VIEW OF THE CHURCH OF THE HOLY APOSTLES, THESSALONIKI, GREECEN HEND

3D DIGITAL REPLICA OF THE CHURCH OF THE HOLY APOSTLES 3D MODEL

SCREENSHOT OF AGISOFT PHOTOSCAN PRESENTING THE SPARSE POINT PRODUCED BY THE ALIGNMENT OF THE IMAGE COLLECTION

GREYSCALE RADIANCE SCALING SHADED VERSION OF THE CHURCH OF THE HOLY APOSTLES 3D MODEL

PROCESSING PIPELINE

The exterior was captured in 3D using the Structure-From-Motion (SFM) and Dense Multi-View 3D Reconstruction (DMVR) methods. Four aerial (utilising hexacopter equipped with gimbal, FPV, GPS and 2of Samsung NX1000 20MP compact DSLR cameras with fixed 16mm and 20-50mm lenses) and terrestrial (using 3-9m camera tripods and custom monopods, distance between capture points 60cm) photo capture sessions were performed during cloudy days. SfM processing - Agisoft PhotoScan (ver. 1.1) using a total of 4090 photos to generated the 3D model.
The processing of the image sequences was performed on two computer systems (CPU IntelCoreI74820K 3.7Ghz, 64GB RAM, Radeon R9 290X, Microsoft Windows 7 64-bit). Additionally, empirical measurements between strong (in terms of visibility) feature points on the surface of the monument were performed and used to scale the 3D model.

ONLINE DELIVERY

X3DOM for lower resolutions, PLY (vertex paint) RAW
The X3DOM framework offers a set of basic 3D viewing functions along with progressive downloading of models as well as support for the binary version of X3D reducing lower downloading times for our landing page visitor. The current version of X3DOM is supported by a wide range of Web browsers over all major OS platforms.

http://www.ipet.gr/~akoutsou/3dicons/index.php?id=ARC3DICONS_3D_1AAP&res=L

MODEL USE

The data produced will be given to the monument's responsible Ephorate in order to be used for any possible internal use. A short demo of visualising the 3D model and performing measurements on its surface along with a short briefing on 3D printing technologies will be made at some point by our institution to the Ephorate's personel which was involved in the procedures of licensing us for digitising the monument.

LICENCE

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NAME OF MONUMENT

CLOISTER OF THE ABBEY OF SAINT MICHEL DE CUXA

LOCATION

SAINT MICHEL THE CUXA, FRANCE

INSTITUTE

CNRS-MAP LABORATORY (UMR CNRS/MCC 3495 MAP)
WWW.MAP.ARCHI.FR

3D POINT CLOUD OBTAINED BY TERRESTRIAL LASERSCANNING

DESCRIPTION

The abbey of Saint-Michel-de-Cuxa (Catalan: Sant Miquel de Cuixà) is a Benedictine abbey located in the territory of the commune of Codalet, in the Pyrénées-Orientales département, in southwestern France. It was an important cultural centre in the regency of Abbot Oliva. Parts of it now makes up the Cloisters museum in New York City. The origins of Cuixà abbey lie at Sant Andreu d'Eixalada abbey, founded in about 840, and located at the head of the Tet valley. In the autumn of 878, the river broke its banks, flooding and destroying the monastery (located near the river-bed) forcing the monks to seek refuge in the surrounding countryside. The community then transferred to Cuixà, a minor cenobitic community dedicated to Saint Germanus, led by Father Protasius. In June 879, Protasius and Miro the Elder, count of Conflent and Roussillon, signed the founding treaty of the new monastery, whereby Cuixà extended its properties with those contributed by Eixalada and Protasius was named abbot. The abbey continued under the protection of the count of Cerdanya and Conflent. The territory then came under the domain of the family of Wilfred I, count of Barcelona in 870. In about 940, under the initiative of Sunifred II of Cerdanya, a new church dedicated to Saint Michael was built. In 956 the building was refurbished and made more sumptuous; the main altar was consecrated on 30 September 974 by Garí, a monk from Cluny who led five southern monasteries. When the Doge of Venice, Pietro I Orseolo, accepted Romuald's advice to become a monk, abdicated his office, and fled in the night, it was to Saint-Michel-de-Cuxa that he retired, accompanied by Romuald and his companion, Marinus, who established a hermitage nearby.

CAPTURE

Time of flight and phase swift laser scanning, terrestrial and UAV-based photogrammetry

EQUIPMENT

Faro Focus 3D, Trimble GX, Nikon D3X, Nikon D300, Copter 4 (surveycopter)

MODELING SOFTWARE

NUBES Forma, Maya

3D POINT CLOUD OBTAINED BY TERRESTRIAL LASERSCANNING

3D POINT CLOUD OF A COLUMN OBTAINED BY MULTI-VIEW STEREO PHOTOGRAMMETRY

3D POINT CLOUD OBTAINED BY UAV-BASED PHOTOGRAMMETRY

PROCESSING PIPELINE

GEOMETRIC RECONSTRUCTION:
Automatic meshing from a dense 3D point cloud (sculpted elements); Interactive and semi-automatic reconstruction based on relevant profiles (existing architectural elements)

MODEL STRUCTURING:
The 3D model has been decomposed in elementary entities, partially hierarchically organized.

VISUAL ENRICHMENT:
Texture extraction and projection starting from photographs finely oriented on the 3D model (Image-based-modeling) ; Texturing by generic shaders.

DATASET STRUCTURE (Geometry):
Single 3D file structured with 1 level of detail

DATASET STRUCTURE (Textures):
Embedded into the 3D geometry file; Stored as external 2D files

ONLINE DELIVERY

WebGL – two interactive 3D models : exterior and interior.

http://3dicons.gamsau.archi.fr/europeana/index.php?VARdr=CUXA_CuxaEglisetextureextfinal_3D_1

http://3dicons.gamsau.archi.fr/europeana/index.php?VARdr=CUXA_CuxaEglisetextureintfinal_3D_1

MODEL USE

Education, virtual exploration, interpretation centre content, and tourism guides

3D MODELING OF THE EXTERIOR AND THE INTERIOR OF THE ABBEY INCLUDING REALITY-BASED TEXTURING

LICENCE

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NAME OF MONUMENT

ENAME ARCHAEOLOGICAL SITE

LOCATION
ENAME, BELGIUM

INSTITUTE
VISUAL DIMENSION BVBA

MEASURING RESISTIVITY AT ENAME

DESCRIPTION

The trade settlement of Ename is founded by the noble family of Ardennes-Verdun around 965 AD as part of the installation of the political and administrative structure of the Holy Roman Empire, created in 962 AD. The settlement grows significantly and gets an impressive stone keep when it becomes the seat of a margraviate around 985 AD to defend the border between the Holy Roman Empire and the kingdom of France. The keep gets destroyed in 1033 AD by the count of Flanders and Ename becomes part of Flanders in 1047 AD. The count of Flanders replaces the trade settlement by a Benedictine abbey in 1063 AD, which remains active until 1795 AD, when the abbey is dismantled and the site is turned into meadows. Excavations start in 1942 for 5 years and continue in 1978 and in the period 1982-2004. Through the study of 30 years of excavations of the medieval trade settlement and abbey of Ename (since 1940s), geophysical research of the archaeological site (2003), complemented by extensive historical studies and research of the historical landscape (since the 1980s), sufficient data was available for a virtual reconstruction of the Ename trade settlement, village and abbey from its conception around 965 AD until today. All virtual reconstructions for the period 1020 to 1730 have been commissioned by the Provincial Museum of Ename in the period 1998-2014. Besides interactive 3D, video and stills of the 3D reconstruction plus photographs of the site and its excavation will be provided. The reconstructions are supported by two blogs, one about the trade settlement and one about the abbey.

CAPTURE

Surveying, excavation, geophysical survey, historical research

EQUIPMENT

Leica TC 600 series Total Station, Geoscan Research RM15 Resistance Meter (resistivity) and Geoscan Research FM36 Fluxgate Gradiometer (magnetometry)

MODELING SOFTWARE

ArchiCAD 6-15, Blender 2, Vue 10-11

AUGMENTED REALITY VISUALISATION OF SAINT LAURENTIUS CHURCH AROUND 1020 WITH PRESENT VIEW (TOP)

PROCESSING PIPELINE

The 3D models were originally hand modelled in ArchiCAD from the plans made by the surveyors. These 3D models, made in the period 1997-2004, have been imported in Blender, where they have been revised, improved, retextured and completed. The terrain has been transformed into terrain maps for Vue, the vegetation (as provided by the expert in historical landscapes) into terrain types for Vue, with the correct types of vegetation and distribution of that vegetation. The buildings, resulting from Blender, have been imported in Vue.
The methodology is explained in detail here. This all yields a 3D scene in Vue that yields outstanding visualisations through rendering. We organise the rendering in a Object VR way (i.e. a camera rotating 360 degrees around a fixed point) and turn the resulting images into an interactive visualisation through the software Object2VR.
In the case of the Ename trade settlement, only the period around 1020 has been reconstructed. The period of 1040, which has been reconstructed in the period 2000-2004, is currently being revised and will not be included in 3D-ICONS. In the case of the Ename abbey, the abbey is rendered for the different key periods, in the historical landscape that surrounds it (1065, 1085, 1150, 1300, 1500, 1595, 1665, 1730). A 4D visualisation combines all periods from 1020 tot 1730 and shows the evolution through time.

EARLY 3D MODEL OF OUTSIDE OF SAINT LAURENTIUS CHURCH

ONLINE DELIVERY

Not online yet. The online delivery will use the software Object2VR, which is HTML5 based. An example of the result can be seen here. Additional results will be still images and videos of the 3D models.

MODEL USE

By providing clickable zones, a lot of information can be provided about the reconstructed period, turning the interactive reconstruction into an explorable world, that can be used for education, virtual exploration, scholarly interpretation and quality tourism.

REAL TIME UNITY 3D VISUALISATION OF SAINT LAURENTIUS CHURCH AND ENVIRONMENT IN 1300

LICENCE

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NAME OF MONUMENT

HOUSE 07, SKARA BRAE

LOCATION
SKARA BRAE, ORKNEY, SCOTLAND, UK

INSTITUTE
CMC ASSOCIATE
WWW.CMCASSOCIATES.CO.UK

DETAIL INSIDE OF HOUSE 07, SKARA BRAE

DESCRIPTION
House 07 is the most preserved of all the dwellings at Skara Brae. Early attempts at restoration resulted in the addition of a modern glass roof. This however has proved troublesome due to damage from increased moisture. It is hoped that further study of the stonework will produce a better solution for long term preservation of the site.

CAPTURE
Terrestrial Laser Scanning - Time of flight and Photography.

We acquired the scan data from Historic Scotland and had no input on the technology or methods used. We did photograph the house for the purpose of creating Quicktime VR films. For this we used a fisheye lens to maximise the panoramic stitching of multiple photographs.

EQUIPMENT
Leica C10, & Leica HDS6100 Scanners
Canon DSLR with 15mm lens

MODELING SOFTWARE
Cyclone, CloudCompare, GeoMagic, Blender, Mudbox.

POINT CLOUD OF HOUSE 07, SKARA BRAE CURTESY OF HISTORIC SCOTLAND

PROCESSING PIPELINE
Scan data was supplied as a Leica project file. We used Cyclone to export aligned point clouds as e57 files. The e57 retained positional data and point intensity values. Each scan was imported to CloudCompare. Points with Intensity <.1 was deleted and then the files were merged and spatially subsampled to .005 Intensity data was then mapped to RGB values and the file sported as a PLY. The coloured point clouds were wrapped in GeoMagic then retopologised with Blender. Contemporary and archive photography was then used to texture the low res models using MudBox and Blender.

COLOURISED DENSE POINT CLOUD MODEL OF INTERNAL FEATURES

ONLINE DELIVERY
None Provided

MODEL USE
Initially for educational resources and teaching packs. Then expand to cover on-site interpretation and site management.

DENSE POINT CLOUD MODEL OF INTERNAL STRUCTURE WITH INTENSITY COLOURISATION

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NAME OF MONUMENT

KUTUKLU BABA TEKKESI

LOCATION
XANTHI, GREECE

INSTITUTE
ATHENA - CULTURAL & EDUCATIONAL TECHNOLOGY INSTITUTE (CETI)
HTTP://WWW.IPET.ATHENA-INNOVATION.GR

COLLECTION OF AERIAL IMAGERY USING A REMOTE CONTROLLED HELICOPTER

DESCRIPTION

The monument is located in the middle of a cultivable area on the west coast of the Vistonida lake in Xanthi, Greece. It is considered as one of the most important Ottoman monuments in the area and it may have been built in the late 15th century. It was possibly built on the ruins of an Orthodox Christian temple that was dedicated to Saint George Kalamitziotis.

CAPTURE:

Combination of Close Range Laser Triangulation (Optec Ilris 36D), Image-Based - Structure from Motion (SfM) and Image-Based - Dense Multi-View 3D Reconstruction

EQUIPMENT

OPTEC Ilris 36D, Samsung NX1000 Camera, UAV, Total Station

MODELING SOFTWARE

Agisoft Photoscan, Meshlab,Blender

DIFFERENT VIEWS OF THE KIOUTOUKLOU BABA BEKCTASHIC TEKKE 3D DIGITAL REPLICA WITH, AND WITHOUT PHOTO TEXTURE

SPATIAL DISTRIBUTION OF A SET OF IMAGE SEQUENCES USED FOR THE GENERATION OF THE SFM-BASED 3D MODEL

MODEL USE

The different versions (geometry and texture resolutions) gives the ability for to the digital replica of the monument to be used in a wide range of applications related to visualisation and dissemination.

PROCESSING PIPELINE

The data collection phase included partial scans using TOF laser scanning, terrestrial and aerial photoshooting along with total station and emperical measurements on strong features on the surface of the monument. The post processing included cleaning and alignment of the partial laser scans, the 3D reconstruction of the image sequences using an SFM implementation (Agisoft Photoscan). Texture mapping was implemented within the SFM software and the 3D model versioning and video sequence generation was performed with the help of Meshlab and Blender.

ONLINE DELIVERY

X3DOM for lower resolutions, PLY (vertex paint) RAW, due to its ability to be visualised to a wide range of Web-browsers without the need of installing any plug-in. Additionally it offers progressive downloading and binary encoding for large models.

http://www.ipet.gr/~akoutsou/3dicons/index.php?id=ARC3DICONS_3D_1Kiou&res=L

SPARSE POINT CLOUD OF THE MONUMENT PRODUCED BY AGISOFT PHOTOSCAN

LICENCE

Creative Commons - Attribution, Non Commercial, No Derivatives.

NAME OF MONUMENT

MAUSOLEUM OF ROMULUS

LOCATION
ROME, ITALY

INSTITUTE
CNR-ITABC. WWW.ITABC.CNR.IT

FARO LASER SCANNER WORKING DURING THE 3D ACQUISITION

DESCRIPTION
The Mausoleum was made by the Emperor Maxentius for his son Romulus. This Mausoleum belongs to a series of monuments like the Pantheon characterized by a common architectonic plan. A small part of the exterior is preserved while the architectonic structure of the interior is completely readable.

CAPTURE
Image-Based - Structure from Motion (SfM)
Terrestrial Laser Scanning - Time of flight
Here the major topic was a comparison between different techniques namely image based and range based. In both cases we had pros and cons, so we decide to proceed with both of them.

EQUIPMENT
CANON 650D, CANON 60D Faro Laser Scanner

MODELING SOFTWARE
Photoscan, Sfera, Geomagic, Rapidform

INTERIOR OF THE MAUSOLEUM OF ROMULUS

FINAL 3D MODEL FOR WEB PUBLISHING

PROCESSING PIPELINE
Photo shooting, laser scanner acquisition, total station acquisition of GCP - Photo selection, referencing based on GCP and dense point cloud extraction - Alignment of point clouds from laser scanner - Hi-poly mesh models from laser scanner and from Photoscan - Textured model from Photoscan - Mesh decimation and conversion of model in X3D for web visualization

ONLINE DELIVERY
X3Dom - This method has been used previous within other projects.

MODEL USE
Tourism and educational/academic purposes.

POINT CLOUD IMAGE BASED OF THE INTERIORS AND EXTERIORS OF THE MAUSOLEUM OF ROMULUS

LICENCE

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NAME OF MONUMENT

SAINT LAURENTIUS CHURCH

LOCATION
ENAME, BELGIUM

INSTITUTE
VISUAL DIMENSION BVBA

EXCAVATIONS IN THE SAINT LAURENTIUS CHURCH (1999-2002)

DESCRIPTION

The Saint Laurentius church was probably built around 995 AD in the new trade settlement Iham (today: Ename) which has been founded around 965 AD. This church has a main nave, two side naves, a double east choir and a west choir.
The church is built in a pre-Romanesque, Ottonian style and is not only one of the oldest standing churches in Belgium, but has been extensively studied and excavated and contains a range of exceptional fresco wall paintings (the oldest in the Low Countries).
The excavations (1999-2002), the detailed research on the building and its history and restoration, provide sufficient data to reconstruct the evolution of the Saint Laurentius church from its conception around 995 AD until today. All virtual reconstructions have been commissioned by the Provincial Museum of Ename in the period 1998-2014. The current virtual reconstructions have been made for the period 1020 to 1730. Besides interactive 3D, video, stills and photographs of the monument and its excavation will be provided. The reconstructions are supported by two blogs, one about the trade settlement and one about the abbey.

CAPTURE

Surveying, excavation, stone by stone analysis by building history experts, historical research

EQUIPMENT

Total Station, non-digital measuring devices

MODELING SOFTWARE

ArchiCAD 6-15, Blender 2, Vue 10-11

AUGMENTED REALITY VISUALISATION OF SAINT LAURENTIUS CHURCH AROUND 1020 WITH PRESENT VIEW (TOP)

PROCESSING PIPELINE

The 3D models were originally hand modelled in ArchiCAD from the plans made by the surveyors. These 3D models, made in the period 1997-2004, have been imported in Blender, where they have been revised, improved, retextured and completed. The terrain has been transformed into terrain maps for Vue, the vegetation (as provided by the expert in historical landscapes) into terrain types for Vue, with the correct types of vegetation and distribution of that vegetation. The buildings, resulting from Blender, have been imported in Vue. The methodology is explained in detail here. This all yields a 3D scene in Vue that yields outstanding visualisations through rendering. We organise the rendering in a Object VR way (i.e. a camera rotating 360 degrees around a fixed point) and turn the resulting images into an interactive visualisation through the software Object2VR. In the case of the Saint Laurentius church, the church is rendered for the different periods in the historical landscape that surrounds it.

EARLY 3D MODEL OF OUTSIDE OF SAINT LAURENTIUS CHURCH

ONLINE DELIVERY

Not online yet. The online delivery will use the software Object2VR, which is HTML5 based.
An example of the result can be seen here.
Additional results will be still images and videos of the 3D models.

MODEL USE

By providing clickable zones, a lot of information can be provided about the reconstructed period, turning the interactive reconstruction into an explorable world, that can be used for education, virtual exploration, scholarly interpretation and quality tourism.

REAL TIME UNITY 3D VISUALISATION OF SAINT LAURENTIUS CHURCH AND ENVIRONMENT IN 1300

LICENCE

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NAME OF MONUMENT

SANCTUARY OF THE IBERIAN OPPIDUM OF PUENTE TABLAS

LOCATION
JAÉN, SPAIN

INSTITUTE
UNIVERSITY OF JAEN, ANDALUSIAN CENTRE FOR IBERIAN ARCHAEOLOGY (UJA-CAAI), SPAIN. WWW.UJAEN.ES/CENTROS/CAAI/

AERIAL VIEW OF THE SANCTUARY OF THE IBERIAN OPPIDUM OF PUENTE TABLAS

DESCRIPTION

The oppidum of Puente Tablas is located 3km from Jaén (Spain). It is one of the most relevant examples of the culture of the Iberians (VI-I ct. b. C.). Undoubtedly it is an example of unique sanctuary in the Iberian Peninsula at the time of the Iberians. According to the Attic red-figure ceramics, it is dated in the first half of the fourth century b. C. The sanctuary covers an area of 300 m2 and it is divided into three terraces partially flag-stoned.
The first terrace consists of cella, antecella and courtyard with the entrance at sanctuary. The second terrace is notable for having a second floor on a side room and especially for the existence to the west of four small caves, three of them in front of a platform with three small holes (probably an altar for libations) with a possible oracular function. The third terrace only has one room, while the rest of the space must be open and connected with a small channel crossing the sanctuary in north-south direction.

CAPTURE:

Image-Based - Traditional Photogrammetry & Dense Cloud Photogrammetry. The data acquisition using photogrammetry require less time and less investment in equipment than others techniques.

EQUIPMENT

Canon EOS 40D & GoPro Hero 3

MODELING SOFTWARE

Agisoft Photoscan

3D MODEL WITH NO TEXTURE OF THE SANCTUARY OF THE IBERIAN OPPIDUM OF PUENTE TABLAS

PROCESSING PIPELINE

Photo Acquisition (250 photos) with coordinates for geo-referencing - Processing pictures (light but first image of tripod is wrong correction, conversion to HDR). - Selection of photos providing better performance when generating the model. - Orientation of photos using Agisoft Photoscan. - Generation of a disperse point cloud with Agisoft Photoscan (total points: 283,157) - Generation of a dense point cloud with Agisoft Photscan (total points: 24,234,925) - Generation of mesh from the dense cloud of points (polygons: 4,866,134) - Through this process we obtain a high resolution 3d model without photographic texture, ideal for viewing on landing pages such as 3dHOP. The simplified model is obtained (decimate mesh), reducing the mesh to a maximum of 300000 polygons. We apply to this simplified model the photographic texture for conversion to 3DPDF model.

ONLINE DELIVERY

3DPDF - Conversion to 3D-PDF produces a format that is easy to handle. 3D-PDF has been widely accepted as the presentation format, because it allows encapsulation and presentation of 3D models with contextual information and links that supply a range of visual angles on the models. Also, this is software compatible with the main operating systems (Windows, Mac OS, Linux).

http://cata.cica.es/archivos/digital_resource_3dicons/6105

3D MODEL WITH NO TEXTURE OF THE SANCTUARY OF THE IBERIAN OPPIDUM OF PUENTE TABLAS

MODEL USE

- Researchers
- Teaching both high school and University
- Dissemination of the culture of the Iberians
- Archaeological routes

POINT CLOUD OF A ROOM OF THE SANCTUARY OF THE IBERIAN OPPIDUM OF PUENTE TABLAS

LICENCE

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NAME OF MONUMENT

SKARA BRAE

LOCATION
SKARA BRAE, ORKNEY, SCOTLAND, UK

INSTITUTE
CMC ASSOCIATE
WWW.CMCASSOCIATES.CO.UK

LASER SCANNING OF SKARA BRAE, COURTESY OF SCOTTISH TEN

DESCRIPTION
Early neolithic site located on Orkney Island, Scotland. Discovered in 1850 after a storm washed away coastal sand dunes. The site was in remarkable condition however it's proximity to the coast places it a great risk from further erosion.

EQUIPMENT
Leica C10, & Leica HDS6100 Scanners
Canon DSLR with 15mm lens

CAPTURE
Terrestrial Laser Scanning - Time of flight and photography. The site was scanned by third parties, we had no influence on the methods or technologies used.

MODELING SOFTWARE
Cyclone, CloudCompare, GeoMagic, Blender, Mudbox.

THE NEOLITHIC SETTLEMENT AT SKARA BRAE, ORKNEY.

PERSPECTIVE VIEWS OF POINT CLOUD MODEL OF SKARA BARE

PROCESSING PIPELINE
We received the scan data as a Leica project file. Using Cyclone we exported each of the scans in two point cloud formats, e57 & PLY. The e57 format allowed us to retain the registration and intensity data. On a house by house basis each of the e57 files were opened in CloudCompare. Data less than. 1 intensity was removed as bad scan records, the files were merged and then spatially subsumed to .005 Intensity data was then converted to RGB and the resulting point cloud exported as a PLY. DISC offered to help with the next section by wrapping the dense clouds with GeoMagic. The triangulated mesh was then opened in Blender and retopologised to produce a lightweight quad mesh. Archive and contemporary photograph was then used to texture the models using Blender & Mudbox.

MODEL USE
We hope to see the data used in three areas:
1. Primary school education packs
2. Tourist interpretative guides
3. Site management and third level studies.

ONLINE DELIVERY
Undecided, fulfilment of 3D will be carried out be Historic Scotland. The scan data is rights controlled, Historic Scotland wanted to mange future sales.

PLAN VIEW OF POINT CLOUD INTENSITY DATA

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NAME OF MONUMENT

ST KEVIN'S CHURCH

LOCATION
GLENDALOUGH, WICKLOW, IRELAND

INSTITUTE
THE DISCOVERY PROGRAMME
WWW.DISCOVERYPROGRAMME.IE

PHOTOGRAPH OF ST KEVIN'S CHURCH

DESCRIPTION

This is the only stone-roofed building to survive at Glendalough and it incorporates a croft between the barrel-vaulted ceiling and the roof which may have functioned as an anchor-hole. It was originally a small rectangular single-celled church with a miniature round tower belfry at the W end. A later chancel and sacristy were added at the E. The roof of the oratory is steeply pitched and corbelled while the outside of the roof stones are roughly dressed to the slope. The only access to the belfry was through the croft which in turn was accessed through a small square hole in the vault. A former wooden floor is indicated by beam-holes on all the walls at the springing of the arch. This room was lit by a small square-headed E window. Only the foundations of the chancel are now visible but the stone-roofed sacristy at the NE angle of the church still stands with a simple lintelled opening in the S wall and a small round-headed window at E. The belfry has one window at each of the two lower floors and rectangular openings on the top floor at the four cardinal points. It was at one stage likened to a chimney and so the church became known as St Kevin's Kitchen.

CAPTURE

Terrestrial Laser Scanning - Phase based. Provides rapid, accurate and dependable building survey data, which can be evaluated onsite. Panoramic Imaging – Provide full image texturing to replace scanner imagery.

EQUIPMENT

Faro Focus 3D
Gigapan Pro, Canon 5D MkII

MODELING SOFTWARE

Faro Scene, Trimble Realworks, Geomagic, Autodesk Mudbox, 3DS Max, XNormal, Photoshop, MeshLab, MARI, PTGUI

IMAGE OF THE DENSE POINT CLOUD MODEL

ONLINE MODELS WITH AMBIENT OCCLUSION MODEL AND PHOTOGRAPHIC TEXTURE MODEL

IMAGE OF ONLINE MODEL LOOKING THROUGH THE DOORWAY INTO THE STRUCTURE OF THE CHURCH

HIGH RESOLUTION MESHED MODEL WITH RADIANCE SCALING RENDER

PROCESSING PIPELINE

Trimble Realworks: Data capture – registration – data cleaning & segmentation –sampling to 1cm – Geomagic: mesh creation -mesh cleaning – decimation to produce addition simplified obj – Mudbox: retopologised smaller obj model – 3DS Max: UV Unwrapped - Mudbox: normal map extracted from high res and applied to low res model – XNormal: ambient occlusion map – PTGUI: Creation of panoramas from multiple images – MARI: texture paining of photographic images onto UV wrap - Photoshop: adjustment of texture maps – MeshLab: Creation of radiance scaling renders

ONLINE DELIVERY

WebGL - Two lightweight models: one with photo texture and one with ambient occlusion to display the structural components of the building, are hosted online using SketchFab. This allows for very short load times and has the ability to generate psuedoVR content for users who cannot use WebGL. SketchFab also allows for First person viewing mode which allows the exploration of spaces.

www.3dicons.ie/index.php/3d-content/sites/26-st-kevins--church-glendalough

MODEL USE

Education, Conservation, virtual exploration, augmented reality, interpretation centre content, and tourism guides, 3D printing, provide access inside building which is normally closed

LICENCE

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NAME OF MONUMENT

TOMB OF THE RELIEFS

LOCATION
CERVETERI, ROME, ITALY

INSTITUTE
FONDAZIONE BRUNO KESSLER (FBK), ITALY.
WWW.FBK.EU

THE SURVEYING TEAM IN THE BANDITACCIA NECROPOLIS WHILE CARRYING THE EQUIPMENT FOR THE SURVEY OF THE TOMB.

DESCRIPTION
The Tomb of the Reliefs, dated IV century B.C., is the most beautiful and well known tomb in the Banditaccia Necropolis (a UNESCO site since 2004) situated northwest of Cerveteri (Rome). The tomb features the typical dromos leading to the entrance. Today the entrance is closed by a steel and glass door which allows the preservation of the micro-climate conditions inside the tomb. Tourists are generally not allowed to enter this tomb.

CAPTURE
Combined TOF scanning and photogrammetric surveys were carried out to obtain the complete 3D model. The TOF range data was used to derive the geometry of the tomb, while the photogrammetric images were used to derive the photo-realistic high resolution texture.

EQUIPMENT
Lens Nikkor 14-24mm
Leica Scan Station 2
DSLR Camera Nikon D3X

MODELING SOFTWARE
Polyworks InnovMetric software
3DS MAX software
In-house FBK software

ONE OF THE COLUMNS INSIDE THE TOMB. IN THE PICTURE IS ALSO VISIBLE THE COLOUR CHECKER CHART USED TO OBTAIN COLOUR CORRECTED IMAGES FOR THE TEXTURE.

PANORAMIC VIEW OF THE INTERIOR OF THE TOMB NAVIGABLE ONLINE WITHIN THE LANDING PAGE.

PROCESSING PIPELINE
All the scans acquired during the survey were aligned together to generate a dense 3D point cloud of the tomb. The cloud was then triangulated to derive a polygonal model (mesh) which was finally textured with a high-resolution image.

ONLINE DELIVERY
A navigable panoramic view of the interior of the tomb is integrated as part of the web page canvas.

http://3dom.fbk.eu/files/3dicons/etruscan_tombs/reliefs_tomb/landing_page/tomb_of_the_reliefs_3d_model_FBK.html

MODEL USE
The 3D model was generated to allow the complete virtual visit of the heritage which is now not always accessible, but visible only through a glass door. The 3D modeling product was used for a multimedia and travelling exhibition in Bruxelles, Trento and Stockholm.

(http://3dom.fbk.eu/en/node/95).

HIGH RESOLUTION TEXTURED 3D MODEL OF THE INTERIOR OF THE TOMB

LICENCE

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NAME OF ARCHITECTURAL FEATURE

CAPITAL OF THE ABBEY NOTRE DAME DE LA SAUVE MAJEURE

LOCATION
LA SAUVE, BORDEAUX, FRANCE

INSTITUTE
ARCHEOTRANSFERT
ARCHEOTRANSFERT.CNRS.FR

PHOTOGRAPH OF THE CAPITAL OF THE ABBEY NOTRE DAME DE LA SAUVE MAJEURE

DESCRIPTION
The Capital of la Sauve Majeure Abbey is a representation of Daniel between two lions. The Grande-Sauve Abbey or Sauve-Majeure Abbey is a former Benedictine monastery near the present village of La Sauve in the department of the Gironde, in a region once heavily forested.

Although now in ruins, the remains of the abbey are still of great interest in terms of Romanesque architecture, especially because of the many sculpted capitals still surviving. In 1998 the abbey ruins were included as part of the UNESCO world heritage site of the pilgrimage route to St. James of Compostela.

CAPTURE
Image-Based - Traditional Photogrammetry. Easy to implement in the location

EQUIPMENT
Nikon D800E

MODELING SOFTWARE
Synaps and Geomagic

CLOSE UP PHOTOGRAPH OF THE CAPITAL OF THE ABBEY NOTRE DAME DE LA SAUVE MAJEURE

TEXTURED 3D MODEL OF THE CAPITAL FOR ONLINE DELIVERY THROUGH WEBGL

PROCESSING PIPELINE
Mulitple photographies, post processing of the images, cleaning of the 3D model.

ONLINE DELIVERY
WebGL - Cross-browser and cross-platform compatibility. Tight integration with HTML content, including layered compositing, interaction with other HTML elements, and use of the standard HTML event handling mechanisms Hardware-accelerated 3D graphics for the browser environment A scripting environment that makes it easy to prototype 3D graphics.

http://archeogrid.u-bordeaux3.fr/3DIcons/3diconsview3d.php?id=15

MODEL USE
Promotion of cultural heritage

DENSE POINT CLOUD MODEL OF THE CAPITAL GENERATED THROUGH SFM

LICENCE

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NAME OF ARCHITECTURAL FEATURE

DAVID DI DONATELLO

LOCATION
MUSEO NAZIONALE DEL BARGELLO, FLORENCE, ITALY

INSTITUTE
ISTI-CNR
WWW.ISTI.CNR.IT

DIGITISATION OF THE STATUE UTILISING A MINOLTA VI 910 CLOSE RANGE SCANNER ON A SCAFFOLD PLATFORM

PHOTOGRAPH OF THE DONATELLO'S DAVID

DESCRIPTION
Marble statue of King David, with the head of Goliath at his feet. The statue is a renaissance masterpiece, and it is one of the earliest work of Donatello. The 3D scanning has been carried out to create a replica for a temporary exposition, since moving the artefact is not possible.

CAPTURE
Close Range Laser Triangulation
The size of the object (human scale) srequired a level of detail between 1mm and 0.3mm, good enough for documentation and physical reproduction, not necessary for study of minute details. Ability to work on scaffolding and to move around the statue easily.

EQUIPMENT
Minolta VI 910 laser scanner

MODELING SOFTWARE
MeshLab

POST PROCESSING - ALIGNMENT OF RANGE SCANS

PROCESSING PIPELINE
- Planning
- On-field acquisition
- Range scan alignment
- Range scan merging
- Hole filling
- Final mesh optimization / cleaning / decimation
- Photographic alignment and color mapping

ONLINE DELIVERY
3D HOP - only tool able to cope with the high-resolution model

MODEL USE
It is not available to the public, only for research purposes, after agreement with superintendence

http://vcg.isti.cnr.it/europeana/david_donatello/landing/david_donatello.html

FINAL HIGH RESOLUTION MESH MODEL

LICENCE
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NAME OF ARCHITECTURAL FEATURE

GRIPHOMAQUIA. SCULPTURE OF THE GROUP OF CERRILLO BLANCO

LOCATION
PORCUNA, JAÉN, SPAIN

INSTITUTE
UNIVERSITY OF JAEN, ANDALUSIAN CENTRE FOR IBERIAN ARCHAEOLOGY (UJA-CAAI), SPAIN. WWW.UJAEN.ES/CENTROS/CAAI/

DATA CAPTURE USING SELF-POSITIONING LASER SCANNER IN THE MUSEUM OF JAÉN

DESCRIPTION

Griphomaquia is a sculpture belonging the group of Cerrillo Blanco (Porcuna, Jaén), undoubtedly the most important group of sculptures attributed to the culture of the Iberians. Dated in the 5th century BC, the sculptures reflect various aspects of an Iberian lineage grouped into different clusters: ancestors, warriors, fighting against animals, hunting scenes, etc. The Griphomaquia is part of a collection of fantastical animals which battled against Iberian hero, who unarmed, grasps the Griffin left ear and nose. At that moment, the Griffin thrusts his claw on the hero's leg.

Height = 70 cm; Width = 84 cm; maximum thickness = 33 cm; Weight = 168 Kg

CAPTURE

Self-positioning laser scanning

Given the relevance of the sculptures of Cerrillo Blanco (in which Griphomaquia is included), we aimed to obtain 3D models using the most appropriate methodology in terms of time, quality and the end use of the models. To do this we started analyzing the conditions under which the sculptures were exhibited. The main problems we faced were:

A - Lighting conditions: Transparency/Reflectance
B - Complex morphology of the object
C - Location and Accessibility:
- Sculptures on raised platforms of a meter high and with little space around (less than 40 cm).
- The weight, the extended visiting hours in the Museum of Jaén and the payment of insurance to move the sculptures make impossible the positional changes.

Given the above limitations, it was decided to discard photogrammetry and to use self-positioning laser scanning as the most appropriate method.

EQUIPMENT

Z-Scann 800 Laser scanner

MODELING SOFTWARE

VX elements, Geomagic 10.0

PHOTO OF GRIPHOMAQUIA

3D MODEL OF GRIPHOMAQUIA

PROCESSING PIPELINE

Import the scanned shots - Merge of the different shots - Fill small holes - Remove spikes
- Export for conversion in PDF

ONLINE DELIVERY

3D PDF
Conversion to 3D-PDF produces a format that is easy to handle. 3D-PDF has been widely accepted as the presentation format, because it allows encapsulation and presentation of 3D models with contextual information and links that supply a range of visual angles on the models. Also, this is a software compatible with the main operating systems (Windows, Mac OS, Linux).

http://cata.cica.es/archivos/digital_resource_3dicons/5898

MODEL USE

Tourism and educational/academic and research purposes.

DETAIL OF POINT CLOUD OF GRIPHOMAQUIA)

LICENCE

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NAME OF ARCHITECTURAL FEATURE

LADISALU HUNYADI'S MARBLE SARCOPHAGUS

LOCATION
SAINT MICHAEL ROMANO-CATHOLIC CATHEDRAL, ALBA IULIA, ROMANIA

INSTITUTE
MUZEUL NAȚIONAL DE ISTORIE A ROMÂNIEI (MNIR)
WWW.MNIR.RO

DATA CAPTURING, JOHN HUNYADI SARCOPHAGUS, SAINT MICHAEL ROMAN CATHOLIC CATHEDRAL, ALBA IULIA

DESCRIPTION
Sarcophagus of John Hunyadi, the brother of Iancu Hunyadi, a Hungarian noble and knight banneret from the House of Hunyadi, who died in 1442.
The funerary monument is located in the southern collateral of Saint Michael Roman Catholic Cathedral, near the Renaissance stair case with the coat of arms built by the bishop Vardai. On the marble sarcophagus Gothic style mythological and biblical battles depict the life of the knight.

CAPTURE
Image-Based - Structure from Motion (SfM) & Traditional Photogrammetry. This 3D digitisation process is a low-cost technique suitable for a museum.

EQUIPMENT
Canon EOS 5D Mk II ISO 100, t=1/60/ zoom lens EF 24-105 AF IS @ 35 mm f: 22

MODELING SOFTWARE
Agisoft Photoscan

TEXTURED MODELS (X3), HIGH QUALITY, AGISOFT PHOTOSCAN

MESH MODEL WIRED, HIGH QUALITY, AGISOFT PHOTOSCAN

PROCESSING PIPELINE
Data capturing with Canon Eos 5D Mark II, - Processing and post - processing in Agisoft Photoscan: photo alignment - build dense point cloud - mesh generating, and texturing.

ONLINE DELIVERY
3D PDF - It is the most suitable solution for this type of visualization

http://mnir.ro/3D/MNIR_3D_12_Idol_2_INV_102326.pdf

MODEL USE
Basic knowledge about the artefacts and also for scientific purpose

ALIGN PHOTOS, GENERATION POINT CLOUD, HIGH QUALITY, AGISOFT PHOTOSCAN

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NAME OF ARCHITECTURAL FEATURE

THE MARKET CROSS

LOCATION
GLENDALOUGH, WICKLOW, IRELAND

INSTITUTE
THE DISCOVERY PROGRAMME
WWW.DISCOVERYPROGRAMME.IE

PHOTOGRAPH OF THE MARKET CROSS INSIDE THE GLENDALOUGH VISITORS CENTER

DESCRIPTION
Now in the Visitor Centre, the 'Market' Cross was reassembled in the 19th century from fragments scattered on the site. It may have originally stood opposite the west doorway of the cathedral. It bears a full-length figure of Christ wearing a crown and dressed in a knee-length tunic. Beneath him is an ecclesiastic and two standing figures, possibly patrons. The cross form is unusual and may have been influenced by Ottonian metalwork. Drilled holes in its stone surface may have held precious jewels, stones or even relics. The artistic style would suggest that it dates to the mid twelfth century.

CAPTURE
Structured Light

EQUIPMENT
Artec EVA

MODELING SOFTWARE
Modelling Software
- Artec Studio, Geomagic, Autodesk Mudbox, 3DS Max, XNormal, Photoshop, MeshLab

IMAGE OF THE PRE AND POST ALIGNED INDIVIDUAL SCANS WITHIN ARTEC STUDIO

ONLINE MODELS WITH AMBIENT OCCLUSION MODEL AND PHOTOGRAPHIC TEXTURE MODEL WITH EMBEDDED ANNOTATION

PROCESSING PIPELINE
EVA: Data capture multiple scans (EVA) – Artec Studio: data cleaning & registration – alignment – registration – surface wrapping – Geomagic: mesh cleaning – decimation to produce addition simplified obj – Mudbox: retopologised smaller obj model – 3DS Max: UV Unwrapped - Mudbox: normal map extracted from high res and applied to low res model – XNormal: ambient occlusion map – Photoshop: adjustment of texture maps – MeshLab: Creation of radiance scaling renders

ONLINE DELIVERY
WebGL - Two lightweight models: one with photo texture and one with ambient occlusion to display the surface morphology are hosted online using SketchFab. This allows for very short load times and has the ability to generate psuedoVR content for users who cannot use WebGL. Also allows for embedded narrative.

www.3dicons.ie/index.php/3d-content/sites/14-the-market-cross-glendalough

MODEL USE
Education, Conservation, virtual exploration, augmented reality, interpretation centre content, and tourism guides, 3D printing of artefacts

HIGH RESOLUTION MODEL WITH RADIANCE SCALING RENDER

3D EXTRUDED PRINT MODEL OF THE MARKET CROSS

LICENCE

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NAME OF ARCHITECTURAL FEATURE

SANTA CRISTINA SACRED WELL

LOCATION
SARDINIA, ITALY

INSTITUTE
THE CYPRUS INSTITUTE, STARC
WWW.CYI.AC.CY/STARC.HTML

SURPHASER LASER SCANNER IN THE FIELD

DESCRIPTION

The archaeological site is one of the most important architectonic representations of the Nuragic culture in the island of Sardinia. It has never been systematically documented and this is the reason for our 3D scanning at the site, i.e. to obtain accurate measurements of the stones, plans of the site and attempt a virtual reconstruction based on this material in order to estimate its original shape.

CAPTURE:
Terrestrial Laser Scanning - Phase based

EQUIPMENT
Surphaser laser scanner, digital camera, total station

MODELING SOFTWARE
JRC, point cloud, autocad, blender, 3dmax

ACCURATE SURVEY NETWORK CONTROL IS CAPTURED IN THE FIELD WITH A TOTAL STATION

VIEW OF POINT CLOUD DATA DISPLAYING THE SUBSURFACE STRUCTURE OF THE WELL

PROCESSING PIPELINE

Various scans were aligned, cleaned, meshed and imported to the various post processing software: JRC for cross sections, measurements, extraction of features, AutoCAD for plans drawing and static calculations, and blender / 3d max for virtual reconstructions.

ONLINE DELIVERY

X3D - most efficient in terms of interaction with 3D model
http://public.cyi.ac.cy/starcRepo/explore/objects

MODEL USE

Provide the possibility to investigate both the above and below ground parts of the structure - useful as an educational tool as well as for comparative research.

IMAGE OF 3D MESHED SURFACE MODEL DERIVED FROM THE POINT CLOUD DATA

LICENCE

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NAME OF ARCHITECTURAL FEATURE

"SUICIDE OF AIACE" METOPE

LOCATION
PAESTUM, CAMPANIA, ITALY

INSTITUTE
FONDAZIONE BRUNO KESSLER (FBK), ITALY.
WWW.FBK.EU

"SUICIDE OF AIACE" METOPE - ORIGINAL ARTEFACT PRESERVED IN THE "MUSEO ARCHEOLOGICO NAZIONALE DI PAESTUM (SA, ITALY)"

DESCRIPTION
Metope carved in sandstone from the Sanctuary of Hera in Sele (Paestum, SA). The artefact is relevant for virtual representation of Magna Graecia and Roman heritage.

CAPTURE
Combined photogrammetric and triangulation-based strip projection scanning surveys were carried out to obtain the complete 3D model.

EQUIPMENT
DSLR Canon EOS 600D + Lens Canon18-55mm
Panasonic DMC-TZ7 Triangulation-based strip projection ARTEC 3DMH scanner

MODELING SOFTWARE
Agisoft Photoscan, In-house FBK software,
Geomagic Studio

3D DATA COLLECTION OF METOPE IN MUSEUM

"SUICIDE OF AIACE" METOPE POINTCLOUD MODEL

PROCESSING PIPELINE
In-house developed and commercial photogrammetric tools were used to generate a dense 3D point cloud of the heritage artefact. The cloud was then triangulated to derive a polygonal model (mesh) which was finally textured with a high-resolution image.

ONLINE DELIVERY
WebGL - The WebGL model is integrated completely into all the web standards of the browser allowing GPU accelerated usage of physics and image processing and effects as part of the web page canvas.
http://3dom.fbk.eu/files/3dicons/paestum_museum/suicide_aiace_metope/landing_page/suicide_aiace_3Dmodel_FBK.html

MODEL USE
The model is not publicly available; it can be released for scientific purposes, by obtaining the permission from the superintendant. The 3D online browser is publicly accessible.

"SUICIDE OF AIACE" METOPE - ORIGINAL OBJ MODEL (HIGH RESOLUTION)

LICENCE
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NAME OF ARTEFACT

CHRYSIPPUS HEAD

LOCATION
TEMPLUM PACIS, ROME, ITALY

INSTITUTE
CNR-ITABC. WWW.ITABC.CNR.IT

PHOTO SHOOTING OF THE CHRYSIPPUS HEAD AT THE TRAJAN'S MARKETS IN ROME

DESCRIPTION

This bronze statue was in the library of Templum Pacis in Rome belonging to a group of portraits of ancient writers and philosophers. The subject of this statue is one of the most important philosophers from the ancient world (he formulated Stoicism into a definitive system). "Chrysippus of Soli (c. 279 BC – c. 206 BC) was a Greek Stoic philosopher.

He was a native of Soli, Cilicia, but moved to Athens as a young man, where he became a pupil of Cleanthes in the Stoic school. When Cleanthes died, around 230 BC, Chrysippus became the third head of the school. A prolific writer, Chrysippus expanded the fundamental doctrines of Zeno of Citium, the founder of the school, which earned him the title of Second Founder of Stoicism." (cit. wikipedia).

CAPTURE
Image-Based - Structure from Motion (SfM)

EQUIPMENT
(Canon EOS 650 with a 18-55 mm lens)

MODELING SOFTWARE
Photoscan, Blender

PHOTOGRAPH OF CHRYSIPPUS HEAD, BRONZE STATUE (HEIGHT 14,5 CM, FLAVIAN PERIOD, 75 TO 80 AC)

IMAGE OF ORIGINAL 3D CAPTURED DATA E.G. POINT CLOUD, MESH MODEL

MODEL USE
Both tourism and academic/no profit educational channels.

PROCESSING PIPELINE
X3Dom - This technology has been used in previous projects of the VHLab.
http://192.167.233.8/emanueldemetrescu/3DICONS/x3d--viewer.php?doi=ChrysippusHead

ONLINE DELIVERY
Photos shooting and reference measures in real world - Photos selection and SfM creation of a hypoly mesh (82M polygons) - Cleaning and hole closing with Meshmixer - Re-import of the model in Photoscan - Low-Poly version of Chrysippus Head (500K polygons) - Texture creation with Photoscan - Import in Blender 3D - Texture correction with digital painting (small artefacts in the upper part of the model and an important integration in the bottom part, hidde during the photo shooting due to preservation issues and permissions from the museum) - Color clustering for specular maps extraction (green parts are oxided bronze) - Extraction of normal maps from HI-poly model - Shader creation combining three channels (diffuse, specular, normal).

IMAGE OF HIPOLYGON MODEL OF CHRYSIPPUS HEAD WITH VERTEX COLOR (92M POLYGONS)

LICENCE

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NAME OF ARTEFACT

EL ARGAR POTTERY

LOCATION
ROYAL MUSEUMS OF ART & HISTORY, BRUSSELS, BELGIUM

INSTITUTE
ROYAL MUSEUMS OF ART & HISTORY (KMKG), BRUSSELS, BELGIUM. WWW.KMKG-MRAH.BE

POTTERY RECOVERD FROM EL ARGAR SITES

DESCRIPTION
Pottery recovered from graves in south east Spain, from El Argar culture. El Argar was a Bronze age culture which thrived, 2200 -1500 BC. The Siret brothers (Belgian mining engineers) working as surveyors in Spain in the 19th century recovered this material in their spare time. The archaeological remains of El Argar are dispersed throughout European heritage institutions, which make it difficult material to study. The 3D models enable remote access and reduce cost and hazard for transportation.

OVERVIEW OF POTTERY SHAPES. ORIGINAL DRAWING OF THE SIRET BROTHERS

CAPTURE
Image-Based - Dense Multi-View 3D Reconstruction
Suitable for this kind of objects.
Limited 3D technical expertise needed.
The museums have their own photographic department therefore only a small investment was required.

EQUIPMENT
Equipment: Nikon D7000 with 60 mm macro lens.

MODELING SOFTWARE
Agisoft Photoscan

POTTERY RECOVERD FROM EL ARGAR SITES

PROCESSING PIPELINE
Object photography, using a hand operated turntable in a white round wall studio (100 - 200 images per object) - In Agisoft Photoscan: Masking the background of individual images - Generation of dense pointcloud - Generation of mesh - Application of texture -Export as 3D PDF & obj

ONLINE DELIVERY
3D PDF - This is the method KMKG applies for 3D digital models

3dicons.kmkg-mrah.be

MODEL USE
The general public will access to low res models through the KMKG website. Researchers will receive high resolution .obj files upon request.

POTTERY RECOVERD FROM EL ARGAR SITES PHOTO CLOUD FOR PRODUCTION OF THE 3D MODEL OF THE POT

© LICENCE / PAID ACCESS - NO RE-USE

NAME OF ARTEFACT

EL ARGAR SKULL

LOCATION
ROYAL MUSEUMS OF ART & HISTORY, BRUSSELS, BELGIUM

INSTITUTE
ROYAL MUSEUMS OF ART & HISTORY (KMKG), BRUSSELS, BELGIUM. WWW.KMKG-MRAH.BE

PHOTO OF THE SKULL WITH THE CROWN

DESCRIPTION
The El Argar buried their dead in burial jars, complete with status symbols like silver crowns, bracelets and beads necklaces. One of the jars still contained a skull wearing a crown. The skull has been reproduced in 3D using photogrammetry.

CAPTURE
Image-Based - Dense Multi-View 3D Reconstruction

- Suitable for this kind of objects.
- Limited 3D technical expertise needed.
- The museums have their own photographic department therefore only a small investment was required.

EQUIPMENT
Equipment: Nikon D7000 with 60 mm macro lens.

MODELING SOFTWARE
Agisoft Photoscan

EL ARGAR BURIAL JAR

THE DEAD WERE BURIED WITH STATUS SYMBOLS

IMAGE OF ONLINE 3DPDF MODEL OF EL AGAR SKULL

PROCESSING PIPELINE
Object photography, using a hand operated turntable in a white round wall studio (100 - 200 images per object) - In Agisoft Photoscan: Masking the background of individual images - Generation of dense pointcloud - Generation of mesh - Application of texture -Export as 3D PDF & obj

ONLINE DELIVERY
3D PDF - This is the method KMKG applies for 3D digital models

3dicons.kmkg-mrah.be

MODEL USE
The general public will access low res models through the KMKG website. Researchers will receive high resolution .obj files upon request.

PHOTO CLOUD FOR PRODUCTION OF THE 3D MODEL OF THE SKULL

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NAME OF ARTEFACT

FURNITURES OF THE PETIT TRIANON 3D

LOCATION
VERSAILLES, FRANCE

INSTITUTE
CNRS-MAP LABORATORY (UMR CNRS/MCC 3495 MAP)
WWW.MAP.ARCHI.FR

3D RECONSTRUCTION BY AUTOMATIC MESHING

DESCRIPTION

The Petit Trianon, built between 1762 and 1768 during the reign of Louis XV, is a small château located on the grounds of the Palace of Versailles in Versailles, France. The park of the Grand Trianon includes the Petit Trianon. The château of the Petit Trianon is a celebrated example of the transition from the Rococo style of the earlier part of the 18th century, to the more sober and refined, Neoclassical style of the 1760s and onward. Within the queen's apartment, one discerns Marie Antoinette's incessant need for privacy: the decor of her boudoir displays an inventiveness unique to the age, featuring mirrored panels that, by the simple turning of a crank, can be raised or lowered to obscure the windows. Her bedroom, although simple, is also elegant in accord with her general style, provided with furniture from Georges Jacob and Jean Henri Riesener. The wallpaper was painted by Jean-Baptiste Pillement.

CAPTURE
Triangulation laser scanning, terrestrial photogrammetry

MODELING SOFTWARE
NUBES Forma, Maya

EQUIPMENT
Konika Minolta Vi-900, Nikon D3X, Nikon D300

3D RECONSTRUCTION BY INTERACTIVE IMAGE-BASED MODELING

3D RECONSTRUCTION BY MESH SEGMENTATION AND IMAGE-BASED TEXTURES

COLLECTION OF 3D DIGITISED FURNITURES

FINAL 3D SCENE OF A ROOM INTEGRATING THE FURNITURES

PROCESSING PIPELINE

GEOMETRIC RECONSTRUCTION:
Automatic meshing from a dense 3D point cloud; Interactive and semi-automatic reconstruction based on relevant profiles, interactive image-based modelling.

VISUAL ENRICHMENT:
Texture extraction and projection starting from photographs finely oriented on the 3D model.

DATASET STRUCTURE (Geometry):
Single 3D file structured with 3 level of detail

DATASET STRUCTURE (Textures):
Embedded into the 3D geometry file; Stored as external 2D files

ONLINE DELIVERY

WebGL – interactive 3D models.

http://3dicons.gamsau.archi.fr/europeana/index.php?VARdr=TRIANON_T1771.1_3D_1

http://3dicons.gamsau.archi.fr/europeana/index.php?VARdr=TRIANON_V967_3D_1

http://3dicons.gamsau.archi.fr/europeana/index.php?VARdr=TRIANON_V3580_3D_1

http://3dicons.gamsau.archi.fr/europeana/index.php?VARdr=TRIANON_W1-38-1_3D_1

http://3dicons.gamsau.archi.fr/europeana/index.php?VARdr=TRIANON_MV3893_3D_1

http://3dicons.gamsau.archi.fr/europeana/index.php?VARdr=TRIANON_V4859_Image_1

http://3dicons.gamsau.archi.fr/europeana/index.php?VARdr=TRIANON_T4654_3D_1

MODEL USE

Education, virtual exploration, interpretation centre content, and tourism guides.

LICENCE

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NAME OF ARTEFACT

THE GODDESS OF SULTANA NEOLITHIC IDOL

LOCATION
MUZEUL NAȚIONAL DE ISTORIE A ROMÂNIE, BUCHAREST, ROMANIA

INSTITUTE
MUZEUL NAȚIONAL DE ISTORIE A ROMÂNIEI (MNIR)
WWW.MNIR.RO

TEXTURED MODEL, LOW QUALITY, CINEMA 4D

DESCRIPTION
The vessel, known as The Goddess of Sultana, is modelled in a human shape. The facial features are under the rim. The eyes are marked by incisions with eyebrows in relief; the mouth is depicted by a large incision with a range of holes into lip and the nose is pointed. The large ears are perforated. The legs are short and thick. Special attention is devoted to the buttocks and the hips, which are emphasized. The schematic arms are modelled in an interesting position: the right arm holds the left one which is reaching toward the chin, suggesting a person who is thinking.

CAPTURE
Image-Based - Structure from Motion (SfM) & Traditional Photogrammetry. This 3D digitisation process is a low-cost technique suitable for a museum.

EQUIPMENT
Canon EOS 5D Mk II ISO 100, t=1/60/ zoom lens EF 24-105 AF IS @ 35 mm f: 22

MODELING SOFTWARE
Agisoft Photoscan

TEXTURED MODEL, HIGH QUALITY, AGISOFT PHOTOSCAN

MESH MODEL, HIGH QUALITY, AGISOFT PHOTOSCAN

TEXTURING, LOW QUALITY, CINEMA 4D

MESH MODEL, HIGH QUALITY, AGISOFT PHOTOSCAN

PROCESSING PIPELINE
Data capturing with Canon Eos 5D Mark II, - Processing and post=processing in Agisoft Photoscan: photo alignment - build dense point cloud - mesh generating, and texturing.

ONLINE DELIVERY
3D PDF - It is the most suitable solution for this type of visualization.

http://mnir.ro/3D/MNIR_3D_12_Idol_2_INV_102326.pdf

MODEL USE
Basic knowledge about the artefacts and also for scientific purpose.

TEXTURED MODEL, HIGH QUALITY , AGISOFT PHOTOSCAN

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APPENDIX 1: ADDITIONAL 3D-ICONS RESOURCES

PROJECT REPORTS

D2.1 Digitisation Planning Report, Paolo Cignioni (CNR) and Andrea d'Andrea (CISA)

D2.3 Case Studies for the Testing the Digitisation Process, Anestis Koutsoudis, Blaz Vidmar and Fotis Arnaoutoglou (CETI) and Fabio Remondino (FBK)

D3.1 Interim Report on Data Acquisition, Gabriele Guidi (POLIMI)

D3.2 Final Report on Data Acquisition, Gabriele Guidi (POLIMI)

D4.1 Interim Report on Post-processing, Livio de Luca (CNRS-MAP)

D4.2 Interim Report on Metadata Creation , A. D'Andrea (CISA) with the collaboration of R. Fattovich and F. Pesando (CISA), A. Tsaouselis and A. Koutsoudis (CETI)

D4.3 FinalReport on Post-processing, Livio de Luca (CNRS-MAP)

D5.1 3D Publication Formats Suitable for Europeana , Daniel Pletinckx and Dries Nollet (VisDim)

D5.2 Report on publication, Daniel Pletinckx and Dries Nollet (VisDim)

D6.1 Report on Metadata and Thesauri Andrea d'Andrea (CISA) and Kate Fernie (MDR)

D6.2 Report on Harvesting and Supply, Andrea d'Andrea (CISA) and Kate Fernie (B2C)

D7.1 Preliminary Report on IPR Scheme, Mike Spearman, Sharyn Emslie (CMC)

D7.2 IPR Scheme, Mike Spearman, Sharyn Emslie and Paul O'Sullivan (CMC)

D7.4 Report on Business Models, Mike Spearman, James Hemsley, Emma Inglis, Sharyn Emslie and Paul O'Sullivan (CMC)

All Project reports are available at fro the 3D-ICONS website at the following

URL: http://3dicons-project.eu/index.php/eng/Resources

PUBLICATIONS

D'Andrea, A., Niccolucci, F. and Fernie K., 2012. 3D-ICONS: European project providing 3D models and related digital content to Europeana, EVA Florence 2012.

D'Andrea, A., Niccolucci, F., Bassett, and Fernie, K., 2012. 3D-ICONS: World Heritage Sites for Europeana: Making Complex 3D Models Available to Everyone, VSMM 2012.

D'Andrea, A., Niccolucci, F. and Fernie K., 2013. CARARE 2.0: a metadata schema for 3D Cultural Objects. Digital Heritage 2013, International Congress, IEEE Proceedings.

D'Andrea, A., Niccolucci, F. and Fernie K., 2013. 3D ICONS metadata schema for 3D objects, Newsletter di Archeologia CISA, Volume 4, pp. 159-181,

Callieri, M., Leoni, C., Dellepiane, M. and Scopigno, R., 2013. Artworks narrating a story: a modular framework for the integrated presentation of three-dimensional and textual contents, ACM WEB3D - 18th International Conference on 3D Web Technology, page 167-175
pdf: http://vcg.isti.cnr.it/Publications/2013/CLDS13/web3D_cross.pdf

Dell'Unto, N., Ferdani, D., Leander, A., Dellepiane, M. and Lindgren, S., 2013. Digital reconstruction and visualization in archaeology Case-study drawn from the work of the Swedish Pompeii Project, Digital Heritage 2013 International Conference, page 621-628
pdf: http://vcg.isti.cnr.it/Publications/2013/DFLDCL13/digitalheritage2013_Pompeii.pdf

Gonizzi Barsanti, S. and Guidi, G., 2013. 3D digitization of museum content within the 3D-ICONS project, ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci., II-5/W1, pp. 151-156.
Online: www.isprs-ann-photogramm-remote-sens-spatial-inf-sci.net/II-5-W1/151/2013/

Gonizzi Barsanti, S., Micoli, L.L., Guidi, G., 2013. 3D Digitizing a whole museum: a metadata centered workflow, 2013 Digital Heritage International Congress (DigitalHeritage), Vol. 2, pp. 307-310, IEEE, ISBN 978-1-4799-3169-9.

Guidi, G., Rodríguez Navarro, P., Gonizzi Barsanti, S., Loredana Micoli, L., Russo, M., 2013. Quick textured mesh generation in Cultural Heritage digitization, Built Heritage 2013, Milan, Italy, pp. 877-882, [Selected for printed publication].

Guidi, G., Rodríguez Navarro, P., Gonizzi Barsanti, S., Loredana Micoli, L., Russo, M., 2013. Quick textured mesh generation in Cultural Heritage digitization, Built Heritage 2013, Milan, Italy, pp. 877-882, [Selected for printed publication].
Online: http://www.bh2013.polimi.it/papers/bh2013_paper_324.pdf

Hermon, S., Bakirtzis, N., Kyriacou, P., 2013. 3D Documentation – Analysis - Interpretation, Digital libraries of 3D data – access and inter-operability, and The cycle of use and re-use of digital heritage assets., Scientific Support for Growth & Jobs (2013): Cultural and Creative Industries, Brussels, Belgium., Session: posters and presentation.

Hermon, S., Ben-Ami, D., Khalaily, H., Avni, G., Iannone, G., Faka, M., 2013. 3D documentation of large-scale, complex archaeological sites: The Givati Parking excavation in Jerusalem, Conference Proceedings, Digital Heritage 2013, Marseilles, France, vol 2, Session: Documentia. Digital Documentation of Archaeological Heritage, pp. 581

Hermon, S., Niccolucci, F.,Yiakoupi, K., Kolosova, A., Iannone, G., Faka, M., Kyriacou, P., Niccolucci, V., 2013. Documenting Architectonic Heritage in Conflict Areas. The case of Agia Marina Church, Derynia, Cyprus, Conference Proceedings, Built Heritage 2013, Monitoring Conservation Management, Milan, Italy, 20 November, pp. 800 - 808.
Available:http://www.bh2013.polimi.it/papers/bh2013_paper_216.pdf [20 Dec 2013].

Hermon, S., Khalaily, H., Avni, G., Reem, A., Iannone, G., Fakka, M., 2013. Digitizing the Holy – 3D Documentation and analysis of the architectural history of the "Room of the Last Supper" – the Cenacle in Jerusalem, Conference Proceedings, Digital Heritage 2013, Marseilles, France, vol 2, Session 3–Architecture, Landscape: Documentation & Visualization, pp. 359 - 362.

Jiménez Fernández-Palacios, B., Remondino, F., Lombardo, J., Stefani, C. and L. De Luca, 2013. Web visualization of complex reality-based 3D models with Nubes, Digital Heritage 2013 Int. Congress, IEEE Proceedings.

Leoni, C., Callieri, M., Dellepiane, M. Rosselli Del Turco, R. and O'Donnell, D., 2013. The Dream and the Cross: bringing 3D content in a digital edition, Digital Heritage 2013 International Conference, page 281-288 - October 2013
pdf:http://vcg.isti.cnr.it/Publications/2013/LCDRO13/DreamAndTheCross.pdf

Niccolucci, F., Felicetti, A., Amico, N. and D'Andrea, A., 2013. Quality control in the production of 3D documentation of monuments, Built Heritage 2013, proceedings
http://www.bh2013.polimi.it/papers/bh2013_paper_314.pdf

Remondino, F., Menna, F., Koutsoudis, A., Chamzas, C. and El-Hakim, S., 2013. Design and implement a reality-based 3D digitisation and modelling project". Digital Heritage 2013 Int. Congress, IEEE Proceedings.

Ronzino, P., Niccolucci, F. and D'Andrea, A., 2013. Built Heritage metadata schemas and the integration of architectural data-sets using CIDOC-CRM , Built Heritage 2013, proceedings
http://www.bh2013.polimi.it/papers/bh2013_paper_318.pdf

Yiakoupi, K., Hermon, S., 2013. Israel Case Studies: The room of Last Supper and The Tomb of King David Hall, Presentation, Digital Heritage 2013, Marseilles, France, Session: "Exploring the 3D ICONS project: from capture to delivery".

APPENDIX 2: PROJECT PARTNERS

Visual Dimension bvba (VisDim) Belgium

Archeotransfert, France

The Discovery Programme Ltd., Ireland

Koninklijke Musea Voor Kunst en Geschiedenis (KMKG), Belgium

Athena Research and Innovation Centre in Information Communication & Knowledge Technologies (CETI), Greece

Centre National de la Recherche Scientifique (CNRS-MAP) France

Muzeul Naţional de Istorie a României (MNIR), Romania

National Technical University of Athens (NTUA), Greece

CMC Associates Ltd., UK

Consiglio Nazionale delle Ricerche (CNR-ISTI), Italy

Politecnico di Milano (POLIMI), Italy

Universidad de Jaen, Andalusian Centre for Iberian Archaeology (UJA-CAAI), Spain

Consorzio Interdipartimentale Servizi Archeologici (CISA), Italy

The Cyprus Research and Educational Foundation (CYI-STARC), Cyprus

Fondazione Bruno Kessler (FBK), Italy

3D ICONS

cip competitiveness and innovation framework programme 2007–2013