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UNDERWATER PHOTOGRAMMETRY AND XML BASED DOCUMENTATION SYSTEM: The case of the 'Grand Ribaud F' Etruscan wreck

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ABSTRACT:

The interdisciplinary work presented here deals with the management of diverse types of information collected during an archaeological excavation, and organized as an XML based data management system. The approach is global, from the consultation of three-dimensional data to simple textual data, and to additional data captured by a digital photogrammetry system called ARPENTEUR, which is now fully integrated to the XML data management system. This work is available on the Internet: http://GrandRibaudF.gamsau.archi.fr

A stratigraphic approach and a set of underwater photogrammetric survey was done after the excavation process. The photogrammetric orientation work was done in Photomodeler 4.0 (camera calibration and bundle adjustment). The final plotting of amphoras and other artefacts was done using the ARPENTEUR software after importation of all camera orientation data from Photomodeler.

The Arpenteur plotting phase is driven by a theoretical model of the measured artefact. The resulting survey is described in a set of XML files containing all measured data (2D, 3D and computed amphoras or artefacts).

At this point, a data management system (based on XML technology) is built in order to access to all the data from 2D or 3D representation of the site on the Internet.

In the framework of multimedia data management system as photographs, indexation of metadata available as XML documents is particularly convenient. Thanks to this formalism we can represent in an homogeneous way a set of very different kind of data such as :

- Structural description of the image content (given by an expert),
- Physical data as color histogram, color zone, (with automatic extraction)
- Photogrammetric data
- Metadata as : intellectual properties, shooting date, policy of right, original support, etc …

This homogeneous representation management of the data coming from different sources is an opportunity to elaborate a request on the whole set of data. On the other hand the results data (also generated in XML) allows a simple and automatic publication of the result towards different media as HTML or PDF for example.

The implementation of such a system has to be done in close collaboration with experts of the investigated domain (here underwater archaeology) in order to build a relevant data model and adapt the request algorithm to the specific problematic.

The XML document structure allows different kind of data indexation :

- Intuitive way, by interactive navigation,
- Simple way as keyword research (for example as search engine, i.e. Google)
- Accurate way by request formalisation as we can do in a traditional DBMS with SQL.

After a brief introduction of the archaeological context, followed by the photogrammetric aspects of the plotting phase with ARPENTEUR, we will then present the existing system and explain the way to navigate into the heterogeneous data as 3D models, theoretical amphora models, oriented photographs and 2D measured points.

1. INTRODUCTION

The management of data is one of the major problems encountered during an archaeological excavation, and presents many types of obstacles:

- The characteristics of the manipulated data are very different, let alone the vital multimedia aspects, and the use of diverse and sophisticated technologies, the latter which poses even more management, presentation, and analysis difficulties;
- Many people are likely to consult the data simultaneously and will possibly update the data;
- These data are likely to change as time goes by, as a result of updates, error checking, and the modification of modelling hypotheses.

The objectives of the work presented here are the synthesis, analysis, and diffusion of knowledge about the excavation at any given moment via the creation of a Web interface. All data are organized in an XML based data management system. The approach is global, from the consultation of three-dimensional data to simple textual data, and to additional data captured by a digital photogrammetry system called ARPENTEUR, which is now fully integrated to the XML data management system.

The originality of the proposed system is principally its dynamic presentation in a Web site, of three main components: (i) an XML data management system ; (ii) a three-dimensional model ; and (iii) a digital photogrammetry tool. The link between these three

components is realised from the conceptual point-of-view, by modelling with the aid of computer tools relying on the object oriented approach (using JAVA 1.4), of a body of objects manipulated by the archaeologist. This computerized approach unites the exchange between the different forms of expression of the objects under study and ensures the coherence between these different expressions (three-dimensional representations ; text ; XML data management ; and assistance for the user during photogrammetric measurement). The state of progress of this work is presented on the following Web site : http://GrandRibaudF.drassm.gamsau.archi.fr[1]
After a brief description of the archaeological context of the Grand Ribaud Etruscan Wreck, we will introduce the Arpenteur photogrammetry tool and its use during the photogrammetry work, then we'll present the XML capabilities and the advantage we got using this formalism to represent both the photogrammetric data and the survey itself.

2. ARPENTEUR GENERAL PRESENTATION

2.1 ARPENTEUR main objectives

ARPENTEUR is a web tool dedicated to architectural and archaeological survey. It has the benefit of the two partner laboratories' expertise in the field of close range photogrammetry and architectural knowledge representation in a survey process. This collaboration is enriching for both researchers and students working on the project.

The main justifications for the project are following:

- As it is the case for education and research software, the JAVA™ development language gives a tool and a technology allowing teams working on different sites and systems far apart,
- As a tool dedicated to architecture, ARPENTEUR profits from expertise of two teams in the field of close range photogrammetry and representation of architectural information.
- As a tool dedicated to photogrammetry, ARPENTEUR is a simple system and should be considered as a light photogrammetry system, light meaning easy to use as well as no heavy equipment required.

The integration of these objectives in the same group implies two technical and conceptual choices. The first is in the use of digital images obtained with a digital camera, now commercially available with adequate resolution. These images also allow automatic tasks and software tools. Finally, they allow the total integration of the process from the images to final results like 3D visualisation in CAO-DAO 3D software.

This integration is made profitable to serve another choice, more conceptual, which is founded on the idea of a process guided by the information related to the field. Concerning both architecture and archaeology, the goal is to allow experts to use their knowledge to produce results which ideally meet their wishes. The results can be shown as documents, visual files, or as a body. For this purpose a group of tools is given to experts to allow them to express hypotheses related to their field of investigation, hypotheses that lead to easier measurement process, e.g. the creation of a body representing the object in its field of investigation.

As a benefit of those choices the ARPENTEUR looks like a tool developed for professional architects and archaeologists with a reduced intervention of the photogrammetry expert. A brief history of this project is developed in [Drap, Grussenmeyer, Gaillard, 2002]

2.2 The Experience of the Grand Ribaud Estruscan Wreck

Among ancient navigators, the Etruscans were the first, in the sixth century B.C., to create an efficient trade network on the south coast of Gaul. Until recently, however, only two pillaged Etruscan wrecks were known to be in the French Mediterranean sea. The 1999 discovery by COMEX (a French commercial diving company) of a wreck loaded with Etruscan amphorae and a general cargo, situated in more than sixty meters of water off the island of Grand Ribaud (Hyères, Var), has brought to light important new data on Archaic period trade and history.

A first survey of the wreck was conducted in October 2000, and a second in August 2001, both directed by DRASSM (the French department of underwater archaeological research) using its research vessel *Archéonaute*. Logistictical support also came from COMEX, which provided its vessel *Minibex*, submersible *Rémora 2000*, remotely operated vehicle *Super Achille*, and prop-washer *Blaster*. In addition, the project was assisted by the French National Centre for Scientific Research (MAP-GAMSAU laboratory). By building on experience gained over nearly fifteen years of work on deep sites, this project allowed further testing and development of new methods, particularly those which do not require divers. In this respect, especially noteworthy are the photogrammetric recording of the visible remains we undertook as well as a test excavation of the central section of the site by gentle prop-washing. These evaluations have confirmed the importance and excellent state of preservation of the wreck, loaded with nearly 1000 amphoras in several layers, stacked bronze basins and disks, coarse Etruscan wares, and high-quality Greek ceramics.

The study of the artifacts has already allowed us to advance some hypotheses about the origin of the amphoras, which all belong to Type Py 4 categorized by F. and M. Py in a 1974 study of imports to the French ports of Vaunage and Villevielle. Although this type seems to be relatively standardized, on the Grand Ribaud wreck there were in fact at least four different *sizes* of the same *shape*. The remains of vine branches and wear marks on the amphorae show that they were secured by dunnage and securely attached to each other by thin ropes. The examination of the amphora clay shows homogenous production, characteristic of southern Etruria.

[1] Grand Ribaud is a small coastal island, not far from Toulon, south of France, where many wrecks of different origins have been found. They have each been assigned an identifying letter, which in the present case is Grand Ribaud F.

While exploiting advanced technologies and technical innovations, it also helps to lay the foundations of a new form of underwater archaeology, one in which divers completely cede their places to remotely controlled devices, given that saturation diving is expensive and increasingly inappropriate for careful excavations on deep-water sites. It is our wish that our site, transformed for the time being into a veritable experimental laboratory, will permit new technologies to work for the benefit of historical and archaeological research.

2.2.1 Digital Photogrammetry

The wreck is resting at a depth of 60 meters ; even if divers are able to go to that depth, the work is very difficult and potentially dangerous. A diver can not stay more than about ten minutes at this depth and to establish a topographic map under those conditions would be near to impossible. We adopted a light digital photogrammetry method by using a non-metric digital camera, mounted in a waterproof housing attached to a bar on COMEX's submarine Rémora 2000. For a light presentation of the underwater photogrammetric method you can refer to [Drap, Long, Durand, Grussenmeyer, 2001-A], [GrandRibaudF, 2000] and more generally to [cipa-uwp, 2002]

2.2.2 The Photogrammetric Results

A total of two hundred pictures have been oriented, with a set of rulers to put them in scale and several buoys for vertical reference. The orientation relative to north is approximated. More than two thousand points were recorded and were used to generate a digital terrain model.

The orientation phase was made with Photomodeler 4.0 and the orientation result were introduced in Arpenteur for a specific survey of the amphorae.
We develop a special bridge from Photomodeler to Arpenteur in order to combine the advantage and specificity of both these software. Photomodeler is actually more efficient to manage a large set of photographs and on the other hand we have been developed a special module for amphora plotting using data fusion from measure and theoretical model. (see [Drap, Long, Durand, Grussenmeyer, 2001-A]).

The main goal was to plot the visible amphorae and fragment, in order to visualise them in the same time that we document the site. All the data surveyed are formalised in XML file which are, in fact, the only result of the plotting phase. We can parse the XML in order to generate 3D representation using VRML, PovRay or MicroStation formalism.

2.3 A DEDICATED DATA MANAGEMENT SYSTEM

The roots of this project reside in the link between many tools and the elaboration of this link through a semantic approach of the objects to be measured and shown. Measurement, representation, and management are articulated around a common model formalized from the « Object » point-of-view and implemented in JAVA 1.4.

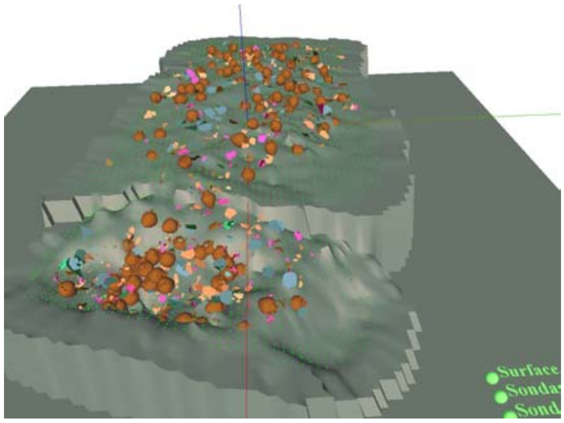

Figure 1. VRML site representation, used as an interface to the archaeological data formalized in the XML result file

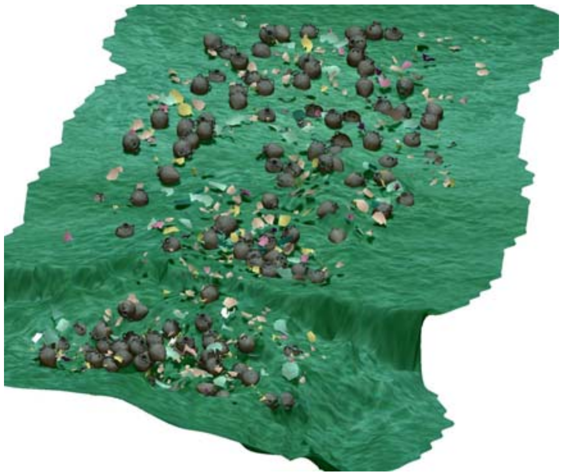

Figure 2. MicroStation site representation, as the VRML one, the graphic file is automatically generated after the parse of data formalized in the XML result file

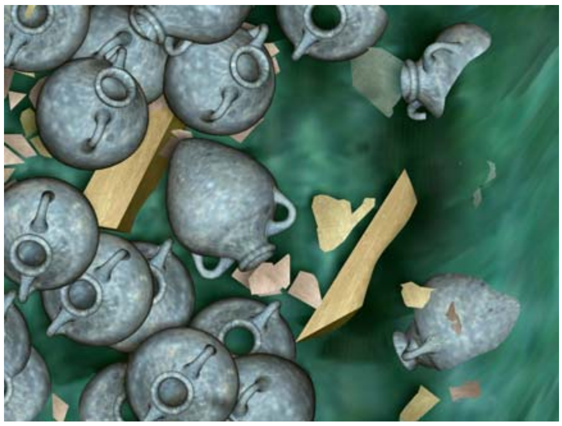

Figure 3. MicroStation site representation. Detail of the last excavation, we can see the bottom of the wreck (wood pieces) and several layer of amphora.

The measurement and representation phases take advantage of this common model by putting in place of a default value mechanism allowing to take complete measurements of the object by using jointly a group of measurements and the generic properties of the type of object studied.

The project is presented on an Internet site (http://GrandRibaudF.drassm.gamsau.archi.fr) which offers at the same time a work interface for archaeologists and a presentation medium of the excavation for the public at large. Access to the archaeological data can be done using the VRML interface and in modification / adding mode by the text interface, protected by restricted access.

3. MANAGING ARCHAEOLOGICAL DATA

In the context of this project a lot of data are produced from various sources. Heterogeneity is one of the main problems of this kind of applications, it can be found at several levels from the data sources to the target format. We mainly focus on three kinds of heterogeneity due to (i) multiple data sources, (ii) differences between objects of study and (iii) changes between versions. The purpose of this section is to describe the troubles at data representation and manipulation level to introduce our data model.

3.1 Heterogeneous data sources

The first kind of heterogeneity comes from the differences between data sources. In our application, they can be divided in two main families whether they are calculated or produced by an expert. The first ones are often well structured (i.e. vector or matrices) whereas the second ones are less structured (natural language), we will call them semi-structured data, it is important that they can be more structured than full text. We are dealing with multimedia data, mainly pictures and semi-structured text.

That is why the data model must provide a way to federate heterogeneous data across multiple data sources. The user must be provided with a unified view of data.

3.2 Dealing with objects specificity

The second kind of heterogeneity comes from the differences between studied objects, for instance between amphora and parts of amphora or even between amphorae themselves. Many data come from pictures, thus if not enough pictures are available, some pieces of information can be missing. Another problem comes from the fact that some object may be incomplete (i.e. broken amphorae).

The data model must also provide tools to express variations between objects from the same class and different level of details in the description of an object.

3.3 Temporal heterogeneity

And last but not least, we have to deal with changes. The changes can take place at several levels from values to data structure. For instance, the values can change between underwater and surface measurements; this kind of changes can be managed with modern database systems. But in our application, the classification of data (i.e. relation between families of objects) and the inner structure of those objects depend on the knowledge of experts and this knowledge can change when new measures are done. The data model must provide an easy way to change the schema of data and application build on top of it must be able to deal with change.

4. USING XML FOR MODELLING PHOTOGRAMMETRIC DATA

For all the reasons presented in the previews section we have chosen XML as our data model. XML is the *de facto* standard for federation and exchange of data between heterogeneous applications. The purpose of this section is to present the main advantages of XML for the description, the manipulation and the presentation of multimedia data in the context of archaeological data.

4.1 XML an adaptive data Model

XML[2] is a recommendation of the World Wide Web consortium (W3C). XML language is designed to associate a tree structure to data. The tree structure is expressed in the data thanks to tags (an opening and a closing tag define an element). A set of attributes can be associated to each element. The content of an element can be either empty of composed of an ordered list of elements and texts.

```
<?xml version=’1.0’?>
<amphora>
  <generalAmphoraDescription
   subClass="PY4-G1"
   type="Col"
   name="Col"
   localisation="surface"
   nbFrgmt="3"
  />
  <photographList>
      <referenceSystemIdentification
    name="PhotoModeler"  />
    <photograph
      num="48"
      camera="NikonCxHz.xml"
      file=" DSC_0022.JPG"
      X="-7403.72775"
      Y="917.997408"
      Z="3531.981572"
      Omega="3.166408809545499"
      Phi="3.2035977616482154"
      Kappa="4.576008655927882"
    />
    …
   </photographList>

   <point3DList>
    <referenceSystemIdentification
     name="PhotoModeler" />
    <point3D pt="OBSERV 1 -7403.728 917.997
3531.982 "/>
    <point3D pt="F_PER 1 -7174.666 1833.136
168.520 "/>
   </point3DList>
   <Remark> Is this some fragments of
      <amphoraRef ref=’29’/>
   </Remark>
</amphora>
```

Figure 4 shows a fragment of XML document, it describes an amphora. One can see that both numerical data (coordinates or 3D points) and textual data (Remark made by an expert) are expressed in the same XML document.

[2] http://www.w3.org/TR/REC-xml

XML makes it possible to describe such data in a single document, and it provides a set of tools to deal with them. In the next section we will present what can be done with these documents.

5. PUBLISHING DATA WITH XML

In the context of this application our objective is to publish the data in different ways.

5.1 A single data source for multiple target

Many different users (from simple visitors to domain expert) will have access to published data. We have to provide them with a view of the data adapted to their needs, that is to say we have to build a dynamic presentation of the data (for example a web-site) depending on the profile of the user.
The presentation also depends on the kind of client: browsing from a workstation, from a handheld device or preparing a printable document.

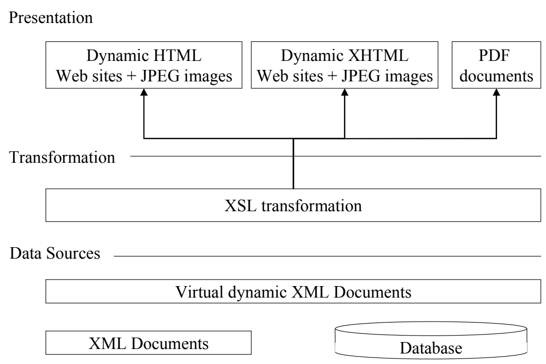

Figure 5. XML publishing framework

5.2 XML publishing framework

XML provide a unified framework to model the data, to transform them, and to present them in a dynamic web-site or in high-quality printed documents. A set a tools has been proposed (each is based on XML):

XSLT[3] (Extensible Stylesheet Language Transformation), is a language dedicated to the transformation of the tree structure of XML document. We are using it to produce every target formats from the sources.

XHTML[4], is a modularized and XMLized version of HTML. We are using it to provide high quality web sites to various clients (from workstations to handheld devices). A classical HTML version will be also provided for backward compatibility.

SVG[5] (Scalable Vector Graphics), is a new generation graphics format. As it is XML based it can be dynamically produced from XML sources. We are using it to produce dynamic maps or to enhance underwater pictures with marks on detected objects (bounding boxes). It can be integrated in XHTML documents to provide interactive graphics (an easy way to browse the data). For older browser those pictures can be dynamically transformed to a bitmap format (the interactive aspect is lost).

X3D[6] (Extensible 3D), this format dedicated to XMLized 3D modelling and adapted from VRML'97 is still under development. We will use it to provide a dynamic 3D view

The whole system will then be XML based the data sources will be dynamically transformed in a web site where the users will browse: presented data, interactive pictures or a 3D model. A high quality printable version of the site will also be generated.
But that may not enough for advanced user. They may need to express their own queries over the data (like in a classical database system).

5.3 Querying XML data

Like SQL for relational database systems, a functional query language is under development for XML, it is called XQuery. The important thing is that if all the data are expressed in XML, XQuery will be a uniform way to query them: photogrammetric data, 3D structure or comments could then used in the same query.
But even if this language will be easy to learn, users must be provided with easier tools to query the data. It will also avoid repetitive construction of complex queries. To do this we will use a dynamic generator of HTML forms, developed for the Multimedia Search Engine (MUSE[7]) project.
With those kind of tools advanced users will be able to define their own view of the data.

6. CONCLUSIONS

This work associates several laboratories working in various disciplines and nevertheless complementary. Teams from with different backgrounds are currently working on the same tool, with the same XML formalism, each every team having taken a few steps towards the others to harmonize the lexicon and to establish a common language.

The management of data, an omnipresent problem in archaeology, is dealt with in two ways: the first one is purely textual and the second is from based on the object geo-referential point-of-view. These two approaches being are accessible over on the Internet.

The use of a three-dimensional model as an interface to the data formalized in XML allows the purely documentary data (references, observations made during the excavation, photographs) to be linked to a three-dimensional representation of the object. This graphic expression of the object relies on the data (position, orientation, dimensions) and on the generic knowledge of the object (theoretical shape, default values, relationships

[3] http://www.w3.org/TR/xslt
[4] http://www.w3.org/TR/xhtml11
[5] http://www.w3.org/TR/SVG
[6] http://www.web3d.org/x3d.html
[7] htp://sis.univ-tln.f/muse

between diverse objects). The three-dimensional model, generated by the system, shows the generic model of the object, defined by the archaeologist, measured by photogrammetry and thereby a relevant interface between the user and the collected data.

In this framework of multimedia data management system, our objective was to publish the data in different ways, XML is the choice we made. Thanks to this formalism we can represent in an homogeneous way a set of very different kind of data such as structural description of the image content, physical data, photogrammetric data.

The result data, generated in XML, allows both a simple and automatic publication of the result towards different media, and a way to elaborate a request on the whole set of data.

This work is available on the Internet http://GrandRibaudF.gamsau.archi.fr

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