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'ARPENTEUR' AS WEB BASED PHOTOGRAMMETRIC PACKAGE: TOWARDS INTEROPERABILITY THROUGH A XML STRUCTURE FOR PHOTOGRAMMETRIC DATA

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ABSTRACT:

After a description of the new photogrammetric developments in ARPENTEUR and some examples of the use of the XML formalism in the general survey process, we'll finish this paper by a call to our community to discuss about a generic XML structure of photogrammetric data. We aim to develop a public Java™ API to manage photogrammetric data through XML files.

A photogrammetric software package available as an applet on the Internet has been developed in the frame of a project called ARPENTEUR (ARchitectural PhotogrammEtry Network Tool for EdUcation and Research) since 1998. It can be easily used on the WEB from anywhere all over the world and with whatever operating system in use. Two servers located in Marseilles and Strasbourg are available to manage project data. The software package is also a Web based tool since photogrammetric concepts are embedded in Web technology and Java™ programming language.

This project is in constant evolution since 1998, several modelling functionalities and possibilities of importation and exportation of data to other applications have been added.

Since ARPENTEUR version 3.0 (January 2002), XML has been chosen to structure the photogrammetric orientation data and to represent the measured data collected during the plotting phase. The aim was to increase interoperability between ARPENTEUR and other software packages.

We propose an XML data structure to represent the data. All photogrammetric data in ARPENTEUR are now stored in XML files. This new feature is a convenient way to share data with other applications:

- Considering the heterogeneous character of the data to be managed in a photogrammetric survey, XML structuring is a good opportunity to federate them in a single document.
- It is then possible to elaborate a request on the whole set of data and write a simple and automatic publication in HTML or PDF.
- The document structure is described in a separate file, what allows the user to seek in the document and get only the relevant information.

As the number of software tools is continuously growing, the photogrammetric field is still missing some common way to provide simple and efficient way to exchange data. This lack of standardisation leads to a waste of time, energy and redundant efforts. As the use of XML formalism has reached a certain level, it appears now as a rational choice. The ARPENTEUR team proposes a standard representation of photogrammetric data through XML and will provide a reference implementation of it. This proposal is a call to other groups, vendors and colleagues to participate to build such a standard.

1. GENERAL PRESENTATION OF ARPENTEUR

1.1 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.

1.2 History of the project

ARPENTEUR is running on the WEB as a Java Applet. The needed file (camera parameters, control points coordinates and images) must be uploaded (by File Transfer Protocol) on one of the ARPENTEUR's servers. Two servers are available with ARPENTEUR Version 2.0 (presently in Strasbourg and in Marseille) reachable from the main web site (<http://www.arpenteur.net>). The user can create his own workspace during the login and upload his data files. Several examples (from architectural or aerial photogrammetry), details about the configuration, help files and papers are available on the ARPENTEUR web page.

Year	Version	Java & plug-ins	Comments
May 1998	1.0	J.D.K. 1.1.5	First version presented at Hakodate (ISPRS Comm. 5)
July 2000	1.1	J.D.K. 1.1.8	Version presented at CATCON (ISPRS Amsterdam)
January 2001	2.0	J.D.K. 1.3 + J.A.I. 1.0.2	Image processing with J.A.I. I-MAGE 3D modeling method

End 2001	3.0	J.D.K.1.3+ J.A.I. 1.1	XML for Document Type Definition
Summer 2002	3.1	J.D.K.1.4 + J.A.I. 1.1	<ul style="list-style-type: none"> ✓ Bridge from Photomodeler™ ✓ XML generalization ✓ Special module for amphora survey in underwater photogrammetry context

Table 1. Evolution of ARPENTEUR since 1998

Abbreviations:

J.D.K.: Java Development Kit

J.A.I.: Java Advanced Imaging

XML: Extensible Markup Language

We plan to upgrade both servers in Marseilles and Strasbourg with the ultimate version of ARPENTEUR in Autumn 2002. It will be possible, with this version to work with photographs stored on the local hard disk.

1.3 Link with other software

Since ARPENTEUR version 3.0 (January 2002), XML has been chosen to structure the photogrammetric orientation data and to represent the measured data collected during the plotting phase. The aim was to increase interoperability between ARPENTEUR and other software packages. We think that it is significant to propose an approach for standardisation. More effective communication between these products will be possible.

We made a bridge from PhotoModeler™ to ARPENTEUR in order to upload photogrammetric data computed with this well known software. We can import both calibrated cameras, measured points and computed orientations. Of course this bridge is completely dependent on the output file format of the target software and can't be portable.

On the other hand, we can export 3D data relating the survey, to VRML format, MicroStation (from Bentley) and POV-Ray. The problem is always the same one: we use an internal format and make several bridges to several visualization software packages.

2. THE XML CHOICE

It is not reasonable to imagine to develop a bridge for all of existing photogrammetric software packages.

From the photogrammetric point of view, we propose XML data structure to represent the data. All photogrammetric data in ARPENTEUR are stored in XML files. This is a convenient way to share data with other applications for two family of reasons:

- considering the heterogeneous data to manage in a photogrammetric survey, a XML structuring is a good opportunity to federate it in a single document.
- It is then possible to elaborate a request on the whole set of data and write a simple and automatic publication in HTML or PDF.

The XML document structure allows different kind of data indexation:

- Intuitive way, by interactive navigation,

- Simple way as keyword research,
- Accurate way by request as we can do in a traditional DBMS with SQL.

The second family of reasons is the intrinsic interoperability structure of XML documents. The document structure is described in a separate file that allows the user to seek in the document and get only the relevant information.

As the number of software tools is continuously growing, the photogrammetric field is still missing some common way to provide simple and efficient way to exchange data. This lack of standardisation leads to a waste of time, energy and redundant efforts. As the use of XML formalism has reached a certain level, it appears now as a rational choice

Example: exporting archaeological surveys in XML

Once the photogrammetric data are formalised with XML, we start to store the plotting result data in the same way. ARPENTEUR has a particular way to manage resulting data, not only as geometrical data but also in a semantic and topologic way.

This approach was implemented in an underwater photogrammetric survey for an Etruscan deep wreck discovered near Marseille two years ago. In this context we develop a special tool for surveying amphora, using a theoretical and geometrical model in order to complete the amphora lacked geometry (due to partial vision or partial destruction).

An XML file is generated in order to manage all measured data concerning the survey.

For more information about this work you can refer [Drap, Long, Durand, Grussenmeyer, 2001-A], and also [Drap, Bruno, Long, Durand, Grussenmeyer, 2002]

3. A MODEL FOR PHOTOGRAMMETRIC PROJECTS

Since the beginning of the ARPENTEUR project, the need to work in a team and with other teams together with an object oriented programming language has obliged us to design our internal tools in a modular fashion, with embedded concepts closely related to general uses in the photogrammetric field, e. g the definition of a so-called Model for photogrammetric projects. To describe this model and reach the goal of interoperability, we use XML and XML Schema languages. The goal of this section is then to show how a photogrammetric model would be formalized using these languages and to propose it as a first step toward a standardized way to describe photogrammetric data.

3.1 The need for a model – Why a Model ?

We all know that when realizing some photogrammetric work, we are dealing with large amount of data, thousands of measures, hundreds of points, etc. All these geometric entities need to be clearly assigned to some usage. A structured representation of data is then a basic requirement to build a photogrammetric software application.

A model is a structured feature that is built to drive a system towards some possible solution of an issue. The concept of Model defines the 'world' of a problem. It clearly establishes what is inside and belongs to the universe of the problem and what should be left outside as non meaningful for it [Lemoigne, 1990]. Such issues in photogrammetry will be surveys, 3D representation or construction of an Information System. For instance, to build an "Information system on heritage conservation" [Camara, Latorre, 1997], structuring of data has been made through a relational data base. That means the existence of a data base schema (a kind of model). In this case, the model remains implicit because it is wrapped in the underlying structure of the data base. The Arpenteur project is using the concept of model as an explicit input to work with data.

3.2 Interoperability

Another point was the ability to exchange data between different teams. Not all the teams use the same software and more than one software may be used in the same team for different reasons like : the software license availability, the preference for a given functionality or simply because of the knowledge of the user. The ability to exchange or share data is also known as the "interoperability" issue and is a concern of the Arpenteur project as a web based tool [Drap, Grussenmeyer, 2000].

Interoperability would allow different teams located in different places to exchange data and to cooperate to some common goal. Other organisations have already begun to build standards or recommendations to reach the interoperability through different systems. Such efforts have already begun in fields that are closed to the photogrammetric field. For instance, in Geographic Information System (GIS), the OpenGIS Consortium has built several specifications to define basic data structure [OpenGIS, 1999] or more sophisticated services, for instance: transformation of coordinates [OpenGIS, 2001]. Another field of interest is the one that deals with 3D representation and reality modelling: the VRML consortium has lead its specification towards standardization : see [VRML, 1997]. This organization is also attempting to develop its new standard by the use of XML Schema (see their draft version at www.web3d.org/TaskGroups/x3d/X3dIndex.html)

3.3 XML and XML Schema : a language dedicated to structured data

Since early stages of the Web, the W3C consortium (<http://WWW.w3c.org/>) has developed many technical specifications for the Web infrastructure as a W3C commitment to promote interoperability. This means encouraging *universal access* to make the Web accessible to all, *semantic Web* to develop a software environment that permits each user to make the best use of the resources available on the Web and a *Web of Trust*.

Among these efforts, "the XML 1.0 Recommendation (published in February 1998) was the first step towards the next generation Web, allowing each community to design languages that suit their particular needs and integrate them harmoniously into a general infrastructure based on XML" (<http://WWW.w3c.org/Consortium/>) The XML specification (Extensible Markup Language, 2000)

describes "a syntax created by subsetting an existing, widely used international text processing standard (Standard Generalized Markup Language, ISO 8879:1986(E) as amended and corrected) for use on the World Wide Web". For that, "XML documents are made up of storage units called **entities**, which contain either parsed or unparsed data. Parsed data is made up of **characters**, some of which form **character data**, and some of which form **markup**. Markup encodes a description of the document's storage layout and logical structure. XML provides a mechanism to impose constraints on the storage layout and logical structure". The XML language defines the concept of well-formedness and validity : a well-formed document simply respects the XML way of structuring elements whereas valid documents respects some constraints on document structure. (Extensible Markup Language (XML) , 2000)

The XML Schema specification (XML Schema Part 0, Part1, Part 2, 2001) is built atop the solid foundation provided by XML and provides a way to define in a separated document (written itself in XML) the structure of entities, their datatypes, the relationships between these entities and constraints as well. The so-called schema gives thus the conditions for a given document to be declared valid with respect to this schema.

4. DESCRIPTION OF PHOTOGRAMMETRIC MODELS

Since the beginning of the year 2002, the Arpenteur team has begun to generalize the use of XML as the core tool to express photogrammetric projects and results. This means that all projects and results can be expressed with XML as a basic storage, although other solutions as SQL data bases can also be used for the data storage.

A first version (validity check) has been developed and is currently used in version 3.0. This version makes use of a DTD (Data Type Definition file) that defines the validity of Arpenteur photogrammetric projects written in XML. A DTD however does neither permit the definition of complex types nor provide the ability of performing uniqueness checking or referential integrity validation. But XML Schema does. The definition proposed here is thus presented through XML Schema for public review and should be understood as a design step in order to provide our community a common way of exchanging data and projects. This will be followed after eventual corrections by a first implementation. We will try to respect a process of open specification-development discussions. Usefull related links and forum addresses can be found at the end of this paper and free tools for reading or validating data documents and projects will be made available as well.

As a short paper like this one is not the right place to show a complete specification, (available on our web site), we will however give the understanding of how is structured a Photogrammetric Model in our schema.

4.1 XML Schema for photogrammetric models

The purpose of a this schema is to define a specialized class of XML documents that deals with photogrammetric data structures. To do that we propose a particular schema for documents referring to

photogrammetric models, easy to by different applications or working teams.

As the reader will convince himself in a short delay, the schema and the resulting documents will be human-legible and reasonably clear (this is one of the goals of the XML specification). As said, the complete schema will not be given here. In place we will present its main elements together with an example that illustrates how projects conforming to this schema will look like. Let us start by considering how the main Photogrammetric Model (Model for short) element is written.

```
<xsd:element name="model">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element name="model-description"
        type="ModelDescriptionType"/>
      <xsd:element ref="orientation-list"
        minOccurs="0" />
      <xsd:element ref="photography-list"
        />
      <xsd:element ref="point2D-lists"
        />
      <xsd:element ref="point3D-lists"
        />
      <xsd:element name="controlPoint-list"
        type="PointList" minOccurs="0" />
      <xsd:element ref="block-list"/>
    </xsd:sequence>
    <xsd:attribute name="version" type="VersionType"
      use="required"/>
    <xsd:attribute name="author" type="xsd:Name"
      use="optional"/>
    <xsd:attribute name="geoSystem"
      type="geoSystemType"
      default="LSR"/>
  </xsd:complexType>
</xsd:element>
```

Table 2 – Excerpt of model definition

4.2 The "model" element

The 'model' element consists of seven subelements, **model-description**, **orientation-list**, **photography-list**, **point2D-lists**, **point3D-lists** and **controlPoint-list** and three attributes, **version**, **author** and **geoSystem**. Each subelements might contain other subelements, and so on until a subelement contains a data rather than any subelement. Elements that contain subelements or carry attributes are known as complex types, whereas elements that contain data are known as simple types.

The types' definition is an XML Schema that enables type checking during document parsing. It allows also the use of a query language (XPath) to assert additional constraints, like uniqueness or referential integrity. For instance, the **model** element defines an Identity constraint on photographs : each **photography** referenced in a **point2D-list** must exists and be already declared in the list of photographs : **photography-list**, in which it must be unique. Other similar constraints (constraints are not shown in the excerpt of the document) apply to referential and their use in **point3D-lists**.

Attributes of the **model** element define the version of the model which is a simple type, roughly a string, that permits recording changes in the model. It is mainly a facility offered to users to be able to agree on the right version of the document to be exchanged. The **author** attribute (optional) gives an indication on the source of the document and the last attribute, **geoSystem** indicates the type of coordinate system that will be used in the model. GeoSystem is a simple type based (restriction of) on the geoSystem type defined in the X3D draft specification (<http://www.web3D.org/TaskGroups/x3d/>). It has a default value of "LSR" meaning Local Space Rectangular. The only other coordinate system currently defined is "GCS" (Global Coordinate System), but other types may be added in the future as well as types derived from the OpenGIS specifications.

4.3 Model subelements

model-description defines a set of attributes that are needed to interpret the next subelements : a **name**, which is the name of the model, a **user** which defines the address where additional resources may be found, a **date** which is the date of creation or update of the model and three attributes (**angle-units**, **ground-units**, **image-units**) that define the units used respectively for angle measurements, for 3D coordinates or length measurements and for image measurements.

orientation-list defines the list of coordinate systems that have already been calculated for this model. This element has a complex type consisting of an **active-ref** element which indicates the identifier of the last coordinate system that was in use when the model was stored, a **bloc-factory** element which enables the definition of a mapping between types of coordinate systems and java implementation (**bloc-factory** is optional) and an unbounded list of **bloc-ref**, i.e. singular or complex coordinate systems already calculated (see below).

photography-list defines the list of photographs currently used in the model. Each photography is defined by an identifier (that must be unique in this list), a reference to a **camera** which is actually defined in another document and thus can be shared with other models in other projects and a reference to a **file** which defines the actual location of the image.

point2D-lists defines a set of lists of point measurements made on the photographs. Each list of points holds a **photo-identifier** that defines the photography used to make the measures on (this photography must exist in **photography-list**, the list of photographs) and then an unbounded list of **point**. A point has a complex type, and several format will be allowed for convenience, see below.

point3D-lists defines a set of lists of points that represent the 3D coordinates of the points obtained when building the model. There is no obligation to decide whether one point must or must not be in one of these lists rather than in another output of the project. Each list holds a **ref-identifier** that defines the actual coordinate system in which the points in the list are expressed, and an unbounded list of **point**. As previously said several formats are allowed for point and we will go in further details below.

controlPoint-list defines an optional list of points that can be used as control points in order to calculate absolute orientation. A single list seems sufficient, but other requirements can make this changed.

Finally, the **block-list** subelement is intended to provide a place holder for the definition of partially oriented models that use bundle block adjustment. A **block-list** is a list of **block** elements, each of them being defined by a **block-identifier** that uniquely identifies the block within the list, a sequence of identifiers referring to existing photographs and a **block-orientation** element. Each **block-orientation** element consists of a **ref-identifier** that refers to an existing coordinate system calculated with the data of this block and an unbounded list of **point-identifier** each referring to existing point measurements in at least one of the photographs of the block.

4.4 Other main elements

bloc-ref mainly consists in the definition of a coordinate system. It can be identified by attributes and holds a subelement that defines a 3D transformation. It can optionally contain a list of single **ref** elements that in turn define 3D transformations. Each of these single **ref** elements defines the transformation to be applied to express data in the coordinate system of the containing **bloc-ref**. For instance, a single **ref** element can define the transformation to be applied to points taken in a relative orientation to express them in an absolute orientation. This hierarchical structuring of coordinate system is not required since the list of single **ref** elements is optional, but it enables the storage of partially oriented blocks or the retrieval of all constructed coordinate systems during calculations occurring during the life of the model. More details will be available online (<http://arpenteur.gamsau.archi.fr/ModelDefinition/index.html>). As for point definition, several formats are allowed to define 3D transformations: they can be defined from angles data (omega, phi, kappa), with matrix format or with one of the definitions given by the X3D draft specification.

Several formats are allowed for point definition. The example below gives a good idea of these possibilities. These are respectively: with attributes for each field, with coordinates as a triplet of double values, with coordinates as an array (coma separated) of double values.

```
<point name="Rel" num="1" ><coord x="-5.454"
y="3.685" z="-13.396" /></point>
<point name="Rel" num="100"><pt> -0.456 1.234 -
5.678 </pt></point>
<point name="Rel" num="2" ><vect> -4.788, 3.161, -
13.113</vect></point>
```

Table 3 – Excerpt of point definition

5. CONCLUSION

We have presented how a photogrammetric project can be seen through the concept of Model and how this model can be formalized into an XML Schema. The purpose of this presentation was to propose such a schema to the

photogrammetric community in order to leverage the ability of exchanging data and projects. This will be especially useful for works that imply data sharing between different teams that must cooperate.

The Arpenteur project will provide an http site where interested individuals, teams or developers can find the complete specification, useful tools to validate photogrammetric projects compared to the proposed schema, a java implementation of the model, a calendar defining steps to accomplish for the specification to complete and a mailing list.

The interested individuals, developers or vendors should try to answer the following question: is there any possibility that would be expected in such a model and that is not covered by this 'description-specification' ?

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