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Pierre Grussenmeyer, Pierre Drap

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Possibilities and limits of Web photogrammetry Experiences with the *ARPENTEUR* web based tool

Pierre GRUSSENMEYER, Strasbourg (France)

Pierre DRAP, Marseille (France)

ABSTRACT

General outlines and experiences from a WEB application dedicated to digital photogrammetry are presented. The project called ARPENTEUR (as Architectural PhotogrammEtry Network Tool for EdUcation and Research) has been started in 1998 by two French research teams of Strasbourg (the "Photogrammetry and Geomatics" group at ENSAIS) and Marseille (the MAP-gamsau CNRS laboratory located in the school of Architecture). The aim of this project is to propose a photogrammetric concept and software embedded in Web technology and Java programming language. Photogrammetry tools and 3D modeling methods are available on the Internet as applets through a simple browser (<http://www.arpenteur.net>). Mainly projects in architectural photogrammetry were presented in the last two years. As an example we present in this paper an application from aerial images, as well as an analysis of the current possibilities available with this technology.

1. INTRODUCTION

Photogrammetric software packages are usually applications installed on computers equipped with WindowsTM or UnixTM platforms. But more and more software packages are available as applets on the Internet with the help of a simple browser. As the applet is based on client-server relations, the software package as well as the data are loaded through the network to run on the client computer. Such tools are not yet very common in photogrammetry or remote sensing. Our project based on JavaTM technologies is called ARPENTEUR (as Architectural PhotogrammEtry Network Tool for EdUcation and Research). The concept of this project has been defined in 1998 (table 1). The photogrammetric and the restitution packages are updated at regular intervals by taking into account the fast developments of JavaTM and its numerous libraries. An overview of the current state of the project is given in this paper.

2. CONCEPT OF WEB PHOTOGRAMMETRY

ARPENTEUR is running on the web [www.arpenteur.net]. To use the package, you need a computer with some basic configuration (mainly JavaTM plug-ins, see § 2.2) and a web browser. Your files (camera parameters, control points coordinates and images) must be uploaded (by File Transfer Protocol) on one of the ARPENTEUR's servers and no data files are stored on your local hard disk.

Within the project, there are two kinds of servers available:

- the HTTP server (Hyper Text Transfer Protocol) is used for the connection to computers equipped with ARPENTEUR (there are presently two possibilities: in Strasbourg and in Marseille). A user can create his own workspace during the login and upload his data files. He can also work with example projects installed on the server;
- the FTP (File Transfer Protocol) server is used to up or download data between the (remote) server and the local computer. Data, result and restitution files can be handled by this means.

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 | Arpenteur 1.0 | J.D.K. 1.1.5 | First version presented at Hakodate (ISPRS Comm. 5) |
| July 2000 | Arpenteur 1.1 | J.D.K. 1.1.8 | Version presented at CATCON (ISPRS Amsterdam) |
| January 2001 | Arpenteur 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 | Arpenteur 3.0 | J.D.K.+ J.A.I. + Java 3D | Visualization with Java 3D XML for Document Type Definition |

Table 1. Evolution of ARPENTEUR

Abbreviations:

J.D.K.: Java Development Kit

J.A.I.: Java Advanced Imaging

XML: Extensible Markup Language

2.1. Presentation of the ARPENTEUR project

The goals of the project are the following:

- as software for education and research, the Java™ programming language includes tools and technology that allow workgroups of several developers or users, from different places and different hardware platforms, and an install-free approach;
- due to the specialization of the two partner groups in Strasbourg and Marseille, the modeling tools are rather developed for close range applications and mainly for the description of architectural knowledge;
- ARPENTEUR is above all a photogrammetric tool and its aim is to propose different solutions for the orientations to photogrammetrists, but also simple methods for non-specialists and a use on standard computers.

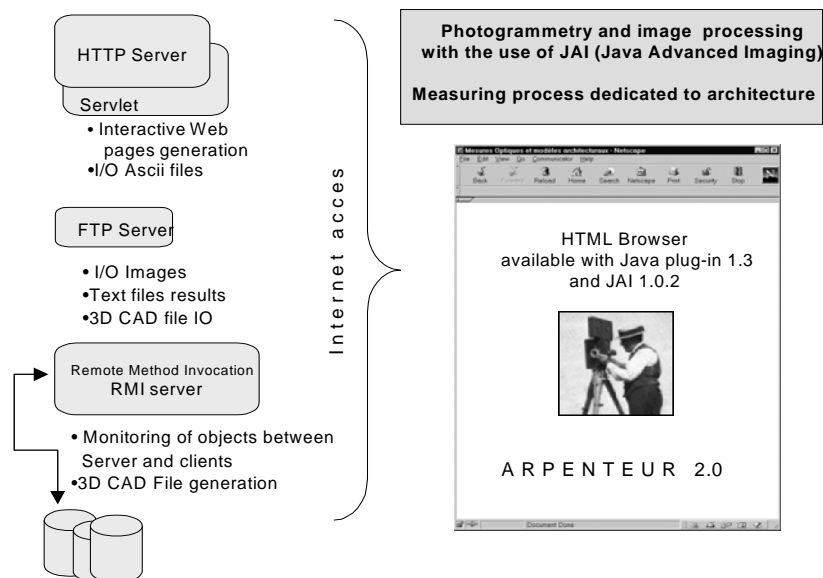


Figure 1. ARPENTEUR's project synoptic scheme

2.2. Configuration

ARPENTEUR is not installed locally on a computer but the package is available as an applet by a simple web browser as NestcapeTM Navigator or MicrosoftTM Explorer.

A web browser is usually able to handle a specific level of Java but this level depends on the version of the browser. Problems will occur if the Java classes installed on the ARPENTEUR servers have a different level in the browser. To avoid errors and to allow the use of any browser, the user must install some plug-ins provided by SUNTM :

- we are currently working with the J.D.K.1.3 [Arpenteur 2.0]. Consequently, the Java2 plug-in is required;
- the Java Advancing Imaging plug-in (J.A.I. 1.0.2.) is also required since classes from this package have been in use;
- the CLASSPATH setting (in the configuration panel under Windows NT/2000, or in the autoexec.bat file under Win95/98) follows in order to indicate the folders containing the plug-ins and the libraries;
- the Java security level of the computer must be changed because the user has to grant the applet to read and write files on the client (local) disk, and this is usually not allowed for common applets. A “.java.policy” file is given and must be copied on the computer.
- we recommend also to activate the so-called Java Console to follow the different steps when running the software. Another file (called “.controlpanel.bat”) is proposed for this activation.

Even if this configuration seems to be a heavy procedure, only a few minutes are required for the configuration. A detailed procedure is given on the project’s web page as an assistance to the configuration. Of course the upgrade of the software package itself is directly done by the administrator on the server and the user always works with the latest version.

2.3. Model management

By starting the software package through the browser, the main frame of ARPENTEUR is loaded. The main frame is divided into four parts:

1. Model management for:

- the selection of an existing model in the current folder;
- the loading of the data files and images (from the server) in the remote computer.

2. Management of the orientation and measuring process to:

- realize the different steps of the photogrammetric orientation ;
- select a modeling module when the orientation is done.

3. ‘System’ window:

- to create new models, configure ARPENTEUR (e.g. size of the correlation matrix), display result files;
- to up-and-download files by FTP between the server and the client;
- to visualize data in a 3D viewer.

4. Java console:

- to display messages and events corresponding to the use of the software package

2.4. Photogrammetric orientations

In aerial photogrammetry the images are equipped with fiducial marks. In our tool, other kind of digital images can also be used :

- simple images from point and shot digital cameras (with a fix focus and without zoom of course)

- images with *réseau* crosses (usually medium or small format metric cameras)

Geometric features of the camera are required from a calibration protocol.

The ARPENTEUR photogrammetric orientation approach is until now mainly based on a two step orientation (relative and absolute orientations). A bundle bloc adjustment has been available since the version 1.4.2. and the measuring process has been based on the measure of homologous points visible on any image pairs from the project.

The usual steps of the workflow are :

1. Model definition and transfer of the image files, camera data and control points to the server;
2. Interior orientation of the images (left and right);
3. Exterior orientation (relative & absolute, or DLT & bundle adjustment);
4. Plotting & restitution or 3D-modeling ;
5. Results files in HTML format (in XML in the version 3.0 of ARPENTEUR), CAD files in DGN format, visualization in VRML or POV-Ray formats.

2.5. Image processing

Several image processing functions can be applied in the different steps. If the camera is equipped with a *réseau*, the crosses are measured automatically. For point measurement, we use the well known area-based correlation (as a combination of the maximum correlation coefficient and correlation in the subpixel range).

Image processing techniques from Java Advanced Imaging API (J.A.I.) are used for manipulating and displaying images. The J.A.I. extends the Java platform for developing image processing applications and applets in Java. It streamlines the process of creating powerful imaging software solutions. The Java Advanced Imaging API 1.0 specifications was developed by Sun Microsystems, Inc., Autometric, Inc., Eastman Kodak, Inc., and Siemens Corporate Research, Inc. It offers advantages for imaging professionals and provides platform-independent and extensible image processing framework.

Since ARPENTEUR 2.0 version, several image editing functions have been proposed to the user (by clicking on the right button of the mouse on each displayed image). For example, the current functions based on this Java library allow:

- to zoom in & out;
- to choose the interpolation method (nearest neighbour, bilinear or bicubic transformation.) used for image manipulation (as zoom for example);
- to handle an image editor for extracting image parts;
- to enhance the image (brightness, color to B/W, etc.);
- to rotate the images in the window;
- to display a magnified additional view for each image (figure 2);
- to display a stereo window to allow the observation of selection of the stereomodel by the so-called anaglyph technique (figure 3);
- to change the shape, the size and the color of the cursor index.

During the restitution, the user can also compute rectified images (based on a predefined plane or cylinder surface). Those images can be directly recorded on the user's computer (and not on the server).



Figure 2. Optional additional views (zoom) for each image, as an example in the window of relative orientation.



Figure 3. Stereo-window in the middle of the screen (anaglyph technique), as an example in the window of absolute orientation.

2.6. Restitution and modeling

Basic modeling possibilities are 3D measurement of points, lines, line-strings, curves and polygons directly available in Bentley's Microstation DGN format, in addition to ASCII files. No stereo measurements are available but homologous points are manually marked on each image. The photogrammetric measure makes use of correlation and display of epipolar lines.

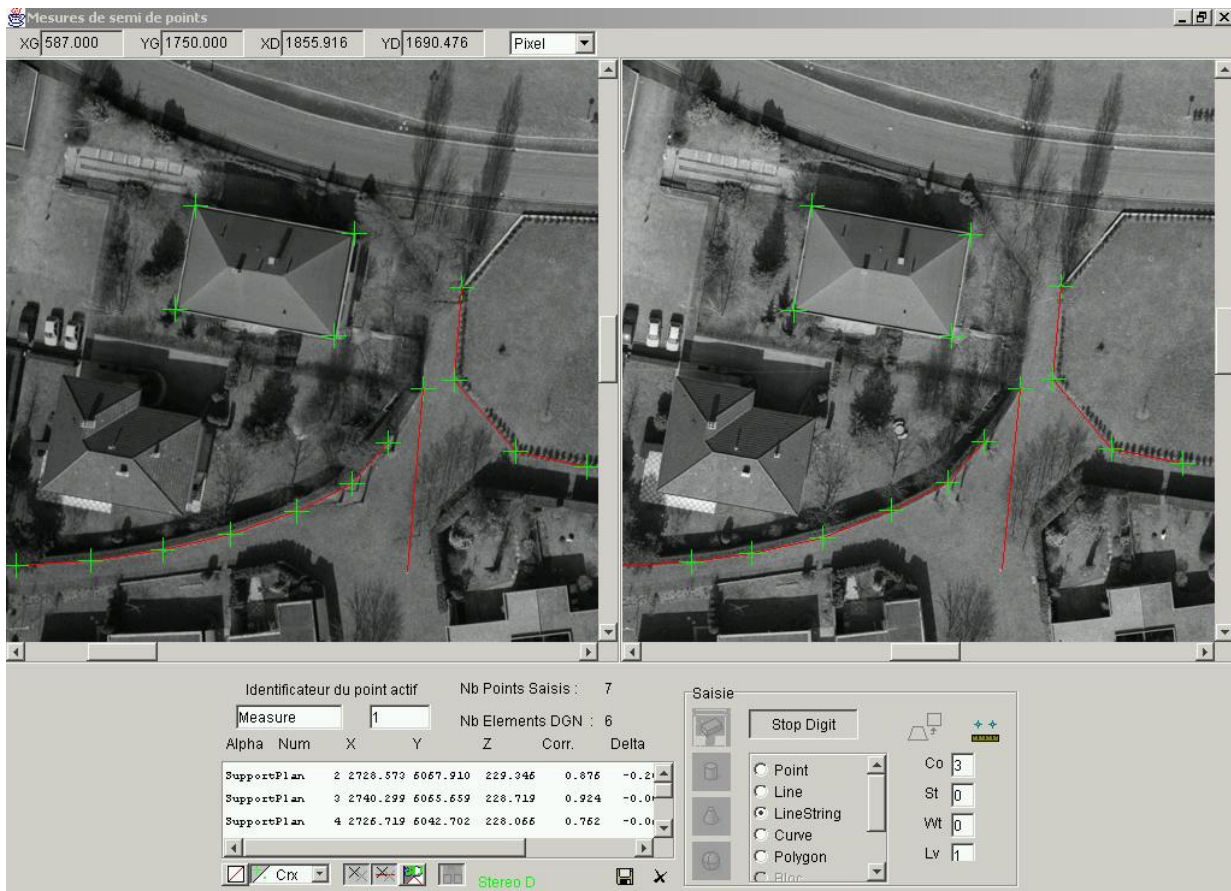


Figure 4. Example of restitution window in ARPEUR

Special 3D modeling modules have been proposed, mainly for applications in architecture:

1. A measurement process based on formalization of architectural and geometrical knowledge for the survey of geometrical primitives of architectural elements was presented at the last CIPA symposium in Olinda, Brazil (Drap et al., 1999).
2. At the ISPRS Congress in Amsterdam (Drap et al., 2000), a so-called 'stone-by-stone surveying method' for the modeling of archeological sites has been introduced. The method is based on the measurement of the visible parts of the stone-blocks. We need of course the approximate depth for each type of stone in order to compute its volume. This data is given in a previous analysis of the edifice with the help of an archeologist. An extrusion vector is computed in order to complete the geometrical description of the stone blocks. A polyhedron representation of the object morphology follows the step of block measurement. Each element is added to a data structure according to topological or geometrical rules. The result is therefore a collection of ordered blocks that includes relations between adjacent blocks.
3. **I-MAGE** method (as **I**mage processing and **M**easure **A**ssisted by **G**Eometrical primitive): for objects based on geometric primitives (as planes, cylinders, cone or sphere shapes), we can combine image correlation and the geometry of the object for the calculation of 3-D points. This **I-MAGE** method is based on four steps, considering that a geometric primitive has been measured from a set of 3-D points visible on a couple of images (figure 5).

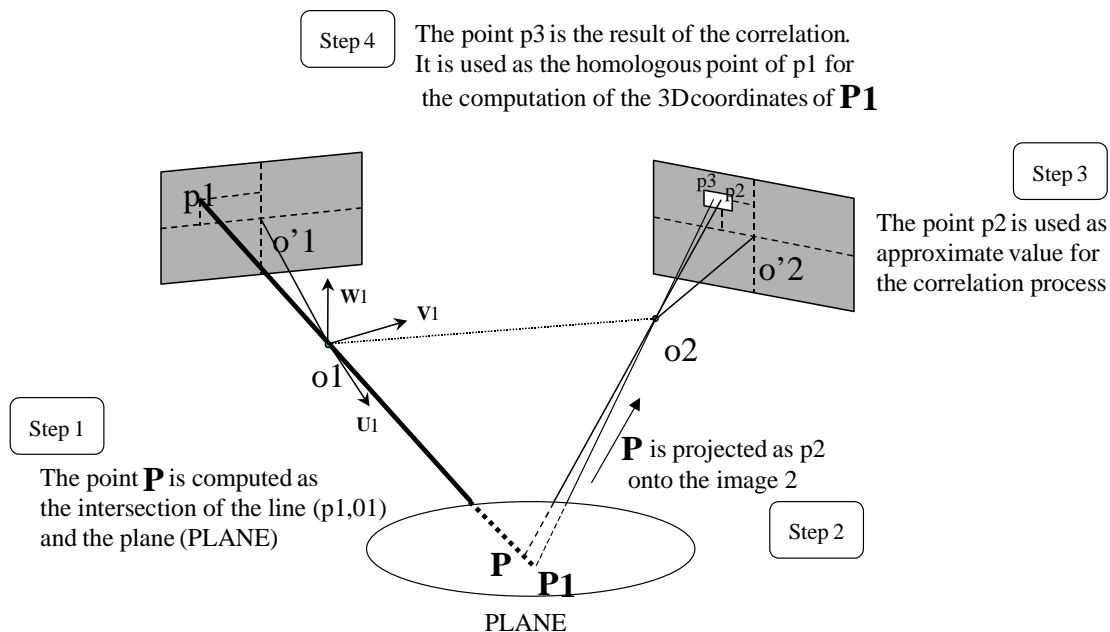


Figure 5. I-MAGE method applied to a plane object

3. POSSIBILITIES, LIMITS AND FUTURE DEVELOPMENTS

The main advantages as well as the present limits in the use of a web based software package in photogrammetry are summarized in table 2.

| Web photogrammetry | |
|--|--|
| Advantages | Limits |
| <ul style="list-style-type: none"> • Install-free approach (only plug-ins to install) • No limit of operating system • Always the latest version is available on the server (no upgrade) • No limit of users • Access to the user project and data possible from any computer at any place and any time • Advantages of Java (true object oriented language) • Powerful classes of Java libraries (J.A.I., Java 3D) • Data storage on the server (not on the local computer) • Use in education and example projects available • Use of XML (structured documents) | <ul style="list-style-type: none"> • Configuration of the computer required (a few minutes only), after download of the plug-ins • Irregular data flow on the Internet (fast Internet required) • Image format usable (GIF recommended, JPG possible but memory consuming) • Limitation for large images • Image processing are time consuming (limits due to J.A.I.) • No stereo measurements • Recent computer with 256 Mo RAM required • Not yet ready for production in photogrammetry |

Table 2. Advantages and limits of web photogrammetry

The potential of Java libraries is great, for photogrammetric applications too. Imaging solutions and processing techniques from Java Advanced Imaging API (J.A.I.) have been used for manipulating and displaying images since 2000. Java 3D based display of three dimensional graphics is projected in the future version for visualization of the measured 3D models.

We are also working on the structure of the information handled in ARPENTEUR. The use of XML technologies has been tested. These technologies have begun to make a big impact on IT systems for the enterprise and the Internet. With the increasing interest in Internet GIS, a similar impact can be expected in the geospatial domain. XML technologies offer many benefits, as for example ease of data transformation and the ability to readily integrate spatial and nonspatial data.

In the version 3.0 of ARPENTEUR, XML “documents” as data, report and result files are built. XML is a markup language for documents containing structured information. A markup language is a mechanism to identify structures in a document. The XML specification defines a standard way to add markup to documents. XML technologies strongly separate presentation and content, and thus are an ideal means to present, understand, manipulate and transfer data between users and applications. This is a first step towards a specification for structured documents in photogrammetry and their use over the web.

4. CONCLUSION

As our concept of web photogrammetry is closely linked to Java and Internet technologies, the level of performance of the network is crucial, above all for the use of large image files in photogrammetry. Several solutions for well known photogrammetric orientations and restitutions are available in our tool, as well as special modules dedicated to architectural photogrammetry. Java libraries offer powerful solutions for imaging, processing and displaying. In the present version, only a few of them have been integrated and there is still a great potential. XML technologies are

used to structure the information in ARPENTEUR and we hope that such a specification will attract photogrammetrist's attention.

During the last months, several connections to our servers have been noted. Some of them were unsuccessful because the configuration of the user's computer wasn't done. For a first test of www.arpenteur.net, we remind users that the installation of plug-ins is required.

5. OTHER REFERENCES ABOUT ARPENTEUR

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