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3D GEOMETRIC MODELING FROM IMAGES ON THE WEB WITH ARPENTEUR

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Abstract. The paper presents the ARPENTEUR project (**AR**chitectural **Ph**otogramm**E**try **N**etwork **T**ool for **Ed**Ucation and **R**esearch). This WEB-based tool has been developed since 1998 and regularly completed and updated according to the evolution of the Java Development Kit proposed by SUNTM. The actual version is working on any browser and any platform updated with the J.D.K. 1.3 plug-in enriched by the Java Advancing Imaging Library (J.A.I. 1.0.2.). Presently two servers in Marseille and Strasbourg (France) are freely available from any computer in the world connected to the Internet [www.arpenteur.net]. Each user has an own workspace on the server in which all his project data (images, camera and control point files, and other input or output files) are stored. Files can be up-or-downloaded within ARPENTEUR by simple File Transfer Protocol available in the main menu. Apart from Internet parameters which are characteristic for such tools on the WEB, specific modules dedicated to photogrammetry and 3D modeling are proposed.

The photogrammetric module is presently based on the orientation of couples of images (not necessarily stereopairs, and not necessarily from metric cameras) and well known steps of interior and exterior orientation. Image processing functions from the Java Advancing Imaging Library as well as an area based correlation method for the measurement of homologous points are included.

The 3D modeling module has been complemented recently by a semi-automated Primitive Measurement Method called **I-MAGE** (Image processing and Measure Assisted by **GE**ometrical primitive). This measuring method is based on the coupling of image correlation and geometric primitives as planes, cylinders, cone and sphere shapes of the object. The resulted 3D models can be visualized either on the internet-oriented VRML plug-ins or inside the MicrostationTM software package.

Projects from any kind of images (terrestrial, close-range as well as aerial images resized to a smaller format for a better handling on the Internet) can be prepared on the Arpenteur' servers and be used as lecture material for groups of students.

Key words: Education, Internet, Java, Object modeling, Photogrammetry, Software, WEB technology

1. Description of the ARPENTEUR project

ARPENTEUR is a digital photogrammetry software package running on the Web developed in the frame of a joint project between GAMSAU (a Laboratory of the French National Science Council) located at the School of Architecture at MARSEILLES and the Photogrammetry and Geomatics Group of ENSAIS-STRASBOURG. The package is intended to be used as a Web based tool since photogrammetric and modeling concepts are

embedded in Web technology and Java™ programming language. Two kinds of servers are 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 Marseilles). A user can create his own workspace in which he can access to example projects or to his own data;
- the FTP server is used to up or download data between the (remote) server and the local computer. Data or result files can be handled by this means.

Several examples, configuration or help files are available on the ARPENTEUR web page (<http://www.arpenteur.net>).

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 partners in Strasbourg and Marseilles, 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.

In photogrammetry, most of the images are equipped with fiducials marks. In our tool, different kind of digital images can be oriented :

- simple images from point and shot digital cameras (with a fix focus and without zoom)
- images with *réseau* crosses (usually medium or small format metric cameras)
- images with fiducial marks (from aerial cameras for example).

Geometric features must of course be given in a calibration protocol or computed by separate software.

As the images are digital, several image processing functions can be applied in the different steps. Correlation tools are changing the way of measuring on images. The modeling process can be simplified by combining the geometric parameters of object entities (primitives as planes, cylinders, spheres etc.) and the measure on the image.

The resulting 3D-models can then be exported to CAD/CAM software packages for further applications. For special applications in architecture or archeology, the objects of the models can be connected to a database, for furthers simulations or queries.

In this paper, the reader will find a general overview of ARPENTEUR corresponding to the current version (Arpenteur 2.0), with some advices for the practical handling of image-models, as well as for the computer configuration with the Java Development Kit (J.D.K.) plug-in's provided by SUN™.

2. Working with ARPENTEUR

2.1. Configuration of the computer

ARPENTEUR is not installed locally on a computer but the package is available as an applet by a simple Web browser as Netscape Navigator or Microsoft 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 problems and to allow the use of any browser, the user must install some plug-ins provided by SUN™ :

- we are currently working with the J.D.K.1.3. 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 are in use;
- the CLASSPATH setting (in the configuration panel under Windows NT/2000, or in the autoexec.bat file under Win95/98) follows than 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 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 10 minutes are required for the configuration. A detailed procedure is given on the project’s web page as an assistance to the configuration and in (Ferhat, 2001). Of course the upgrades are directly done by the administrator on the server and the user always works with the latest version.

2.2. Photogrammetric tools

The ARPENTEUR photogrammetric orientation approach is until now mainly based on two step orientations (relative and absolute orientations), applicable to a model of 2 images (stereo or convergent). Multi-image measuring is not available until now.

For the measurement of homologous points, we use area-based correlation as a combination of the maximum correlation coefficient and correlation in the subpixel range.

The usual steps of the orientation are :

- Model definition and transfer of the image files, camera data and control points to the server;
- Interior orientation of the images (left and right);
- Exterior orientation (relative and absolute);
- Plotting and 3D-modeling;
- Results files are written in HTML format, CAD files in DGN, and VRML or POV-Ray formats are also proposed.

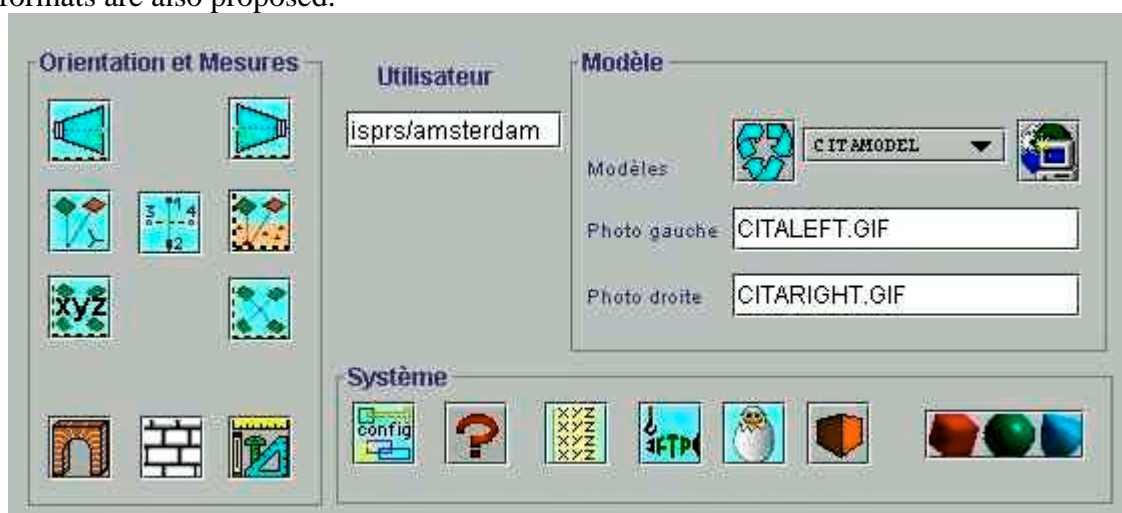


Figure 1. Main window of ARPENTEUR after selection of a model

More details about the photogrammetric tools have been presented in previous papers (Drap & Grussenmeyer, 2000). Help files and papers are also available at www.arpenteur.net .

2.3. 3D modeling tools

Basic modeling possibilities are 3-D measurement of points, lines, line-strings, curves and polygons directly available in Bentley's Microstation DGN format, in addition to ASCII files.

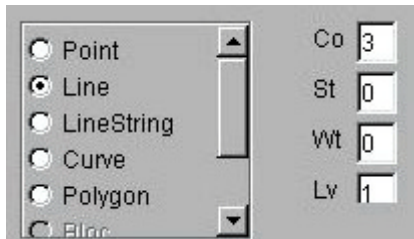


Figure 2. Configuration of 3-D data.

For objects based on geometric primitives as planes, cylinders, cone or sphere shapes, we can apply for the calculation of 3-D points a method which is coupling image correlation and the geometry of the object. This method called **I-MAGE** (as **I**mage processing and **M**easure **A**ssisted by **G**Eometrical primitive) 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 :

- a point **P** can be computed from one image by intersection of an image ray (p_1, O_1) and the geometric primitive (the plane in figure 3 is defined by 4 parameters in an earlier process from a set of 3-D points);
- **P** is projected as p_2 onto the second image;
- The point p_2 is used as approximate position to initiate the area based correlation process;
- The point p_3 is the result of the correlation; p_1 and its homologous p_3 are used for the computation of the 3-D coordinates of **P1**.

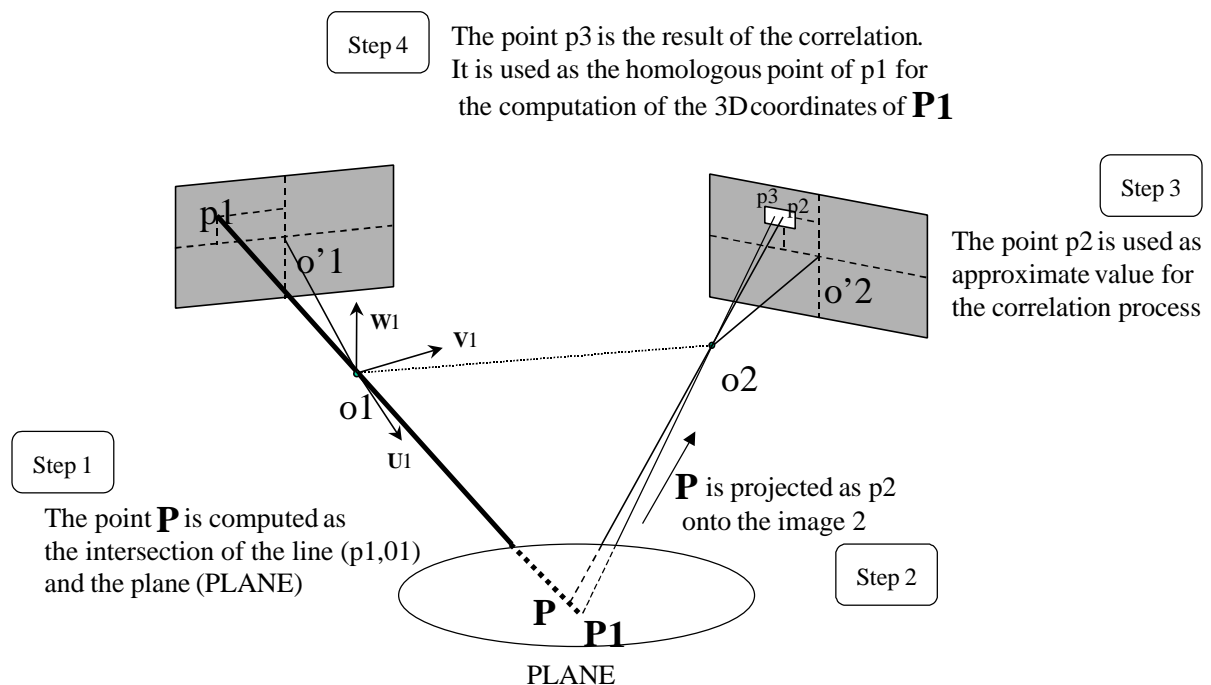


Figure 3. I-MAGE method applied to a plane object

For each computed primitive, the user can guide and follow the different steps of the measuring process :

- in a special window (figure 4), where the different parameters are displayed.
- 3D-coordinates of P and P1 can be compared
- on the images: mass points are measured on only one image (p1) and the computed homologous points are displayed on the second image (p3) as a visual control.

There are at least two advantages in the use of I-MAGE for objects defined by geometric primitives :

- the measurement process is simple, interactive and fast;
- the process allows accurate analysis of the object geometry and can be used to control the geometry of object corresponding to primitives.

This module has been applied to the modeling of the house presented as an example in §3, where the house roof and elevation-faces have been modeled as planes.

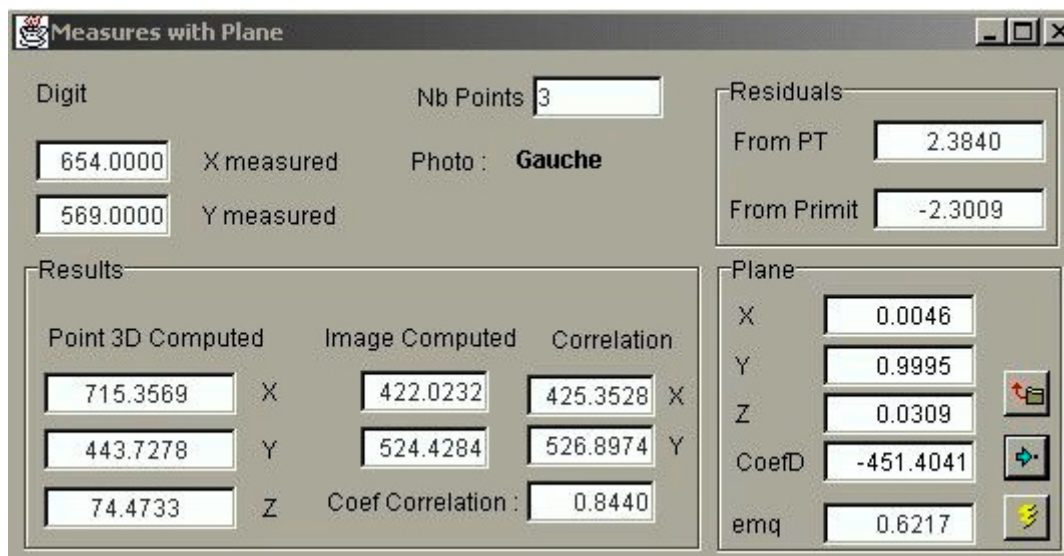


Figure 4. Window of I-MAGE, showing the measures and the computed parameters for an object defined as a plane.

3. 3D geometric modeling from images: example of small size object for education

3.1. Data set

The following data set (LEGO house in figure 5) is given as an example which can easily be prepared for training students. The object is here mainly made of planes (walls, roof).

Images can be taken as stereo pairs or oblique shots to cover the whole object. Control points in 3D are directly measurable with a tape on the object with an accuracy of 1mm.

The parameters required for the digital camera (coordinates of principal point and focal length, chip size or coordinates of the chip corners and pixel size, radial distortions) are written in a so-called camera file.

As a summary, the following files are required and must be up-loaded on one of the servers in the user's workspace (example files are available on www.arpenteur.net , anonymous login):

- image files (accepted formats are GIF or JPG);
- camera file (filename.cmr, as a text file);
- control point file (filename.cal, as a text file).

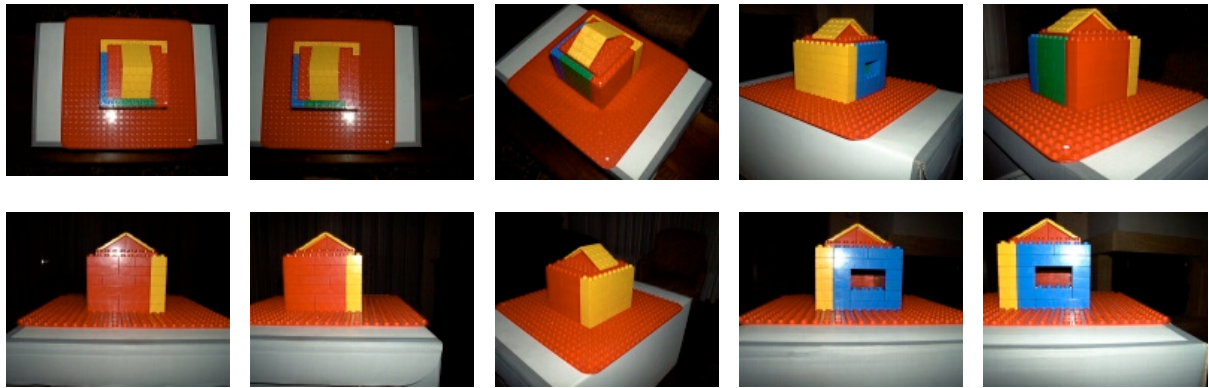


Figure 5. Selection of color-images taken with a non-metric (but calibrated) digital camera.

The photogrammetric orientations and CAD models have been prepared in Strasbourg in spring 2001 by Georgiadou Ioanna and Matsouka Eleni, ERASMUS students from Aristotle University of Thessaloniki, Greece.

3.2. Photogrammetric models

In order to plot the different elements of the house, the project has been divided in different models. For each model (made of 2 images), the user follows the steps of the interior, relative and absolute orientation. A detailed user guide for the orientation of a photogrammetric model with Arpenteur has been prepared by Ferhat (2001).

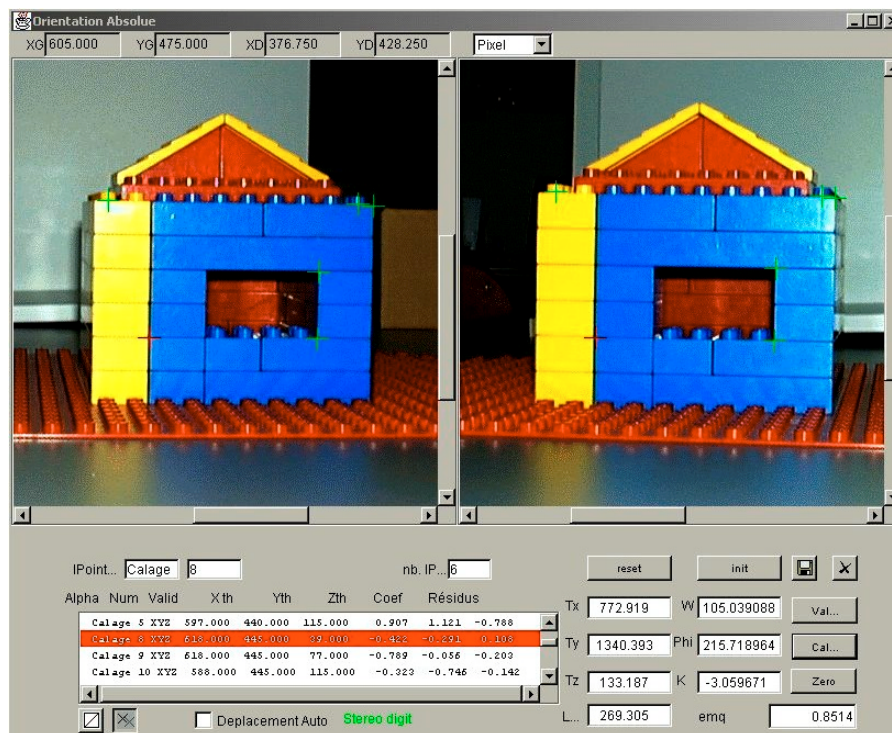


Figure 6. Window of the absolute orientation of a model

3.3. Geometric modeling

For each oriented pair of images, simple measurements of points or lines (see the options in figure 2) and semi-automated measurements based on primitives (here only planes) with I-MAGE have been applied (figure 7). The user can take advantage of the colors of the LEGO house for the setup of layers and colors in the CAD file during the modeling process. The

object can be divided in different surfaces (four vertical surface walls and two oblique roof surfaces) and completed with additional points and lines in order to get the final wireframe model.

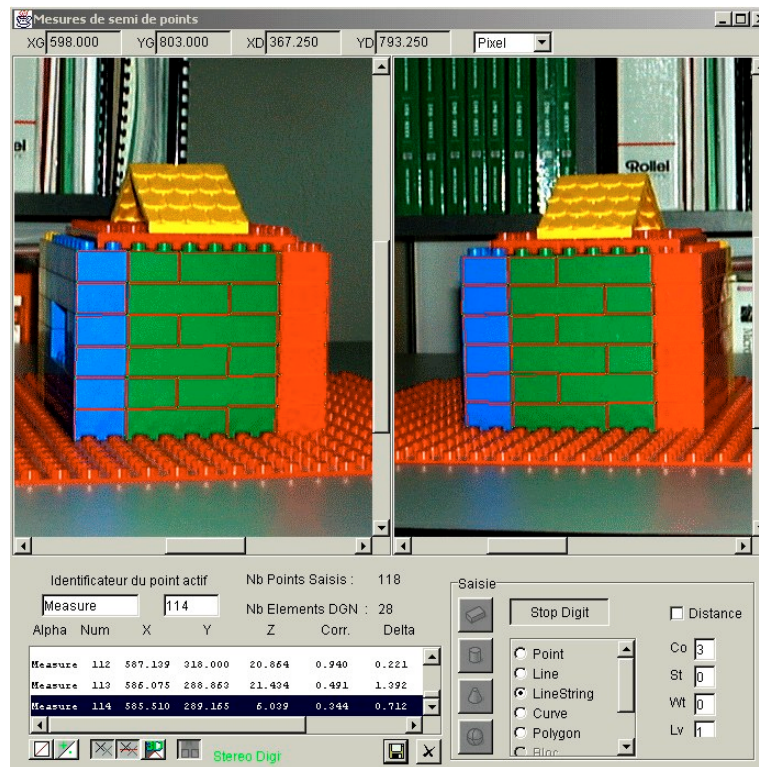


Figure 7. Modeling an object-plane with I-MAGE

Orientation files and coordinate files are available as HTML or text files. The 3D model is proposed in three different formats : Microstation DGN, VRML and POV-Ray. As usual, these files are downloaded from the server to the user's computer by FTP.

The example presented in figure 8 is the result of the merging of the different DGN files in one Autocad DWG file. The method used was the insertion of a block e.g. the entering model is considered to be a block in the same scale as the existing one.

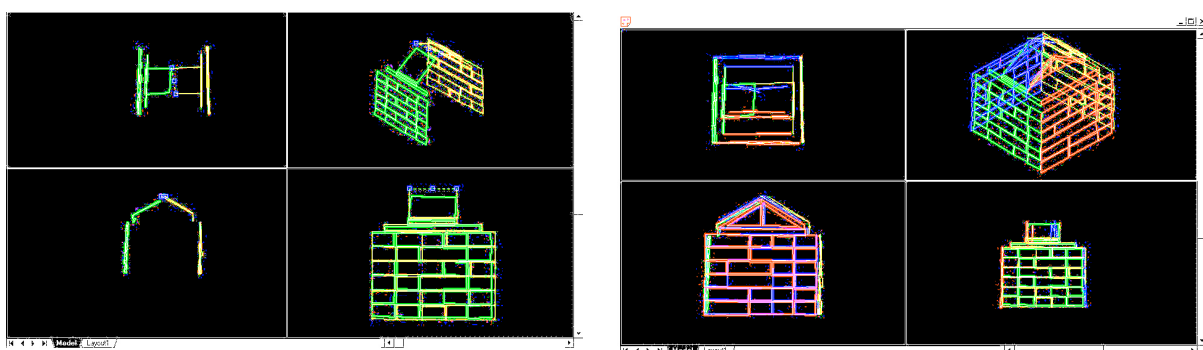


Figure 8. Collection of the different drawings from the ARPENTEUR models

4. Conclusion

The use of WEB-based tools is not yet frequent in practical works with students. Every one agrees that the performances of the network tools are sometimes irregular, and as a consequence no real production work is currently possible in WEB-photogrammetry with large format images. In the example presented in this paper, the image size was limited to 700Ko (from a standard digital camera) and there was no limit in the process.

An overview of photogrammetry and modeling tools have been described in this paper, as well as an application on a simple object. For a use in education, there are several advantages to prepare the project with WEB tools:

- data storage is done on the server
- there is no limit of users (no problem of licenses)
- access to the user data and project is possible from any computer at any time
- the latest version of the software is always available on the server
- example projects are available.

Basic configuration is just required on computers for the use of ARPENTEUR (in fact the installation of the Java plug-ins). These plug-ins contain powerful classes required by the package. Imaging solutions and processing techniques from Java Advanced Imaging API (J.A.I.) are used for manipulating and displaying images. Java 3D based display of three dimensional graphics is projected in a future version.

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