ARPENTEUR : an **AR**chitectural **P**hotogramm**E**try **N**etwork **T**ool for **E**d**U**cation and **R**esearch

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Commission V, Working Group V/5

KEY WORDS : Digital Photogrammetry, Object-Technology, knowledge Representation, Web Technology, Education, Architecture.

ABSTRACT : ARPENTEUR is an application for digital photogrammetry dedicated to architecture. Everybody can access ARPENTEUR via the internet. This software is an extension of the TIPHON software developed at ENSAIS. [Morot, Grussenmeyer, 1996]. ARPENTEUR is a software based web technology, HTTP server, FTP server and communication with a remote computer using IP protocol. The photogrammetric calculation and image processing routines are written in Java™. The photogrammetric and architectural data are managed using an OODBMS (PSE Pro / Object Store from Object Design™). Traditional steps of internal, relative and absolute orientation are used to get a photogrammetric model. Java environment with its tool kit allows us to elaborate some utilities in order to automate the measuring process (fiducials marks, reseau, homologous points) with image correlation.

RESUME : ARPENTEUR est une application de photogrammétrie numérique dédié à l'architecture et accessible à tous via le réseau internet. Il est le prolongement sur Internet du logiciel de photogrammétrie TIPHON développé à l'ENSAIS [Morot, Grussenmeyer, 1996]. ARPENTEUR est basé sur la technologie Web, serveur HTTP, serveur FTP, communication entre machines sur le protocole IP. Les calculs photogrammétriques et les traitements d'images sont développés en JAVA™. Les données photogrammétriques et architecturales sont gérées par un SGBDOO (PSE / ObjectStore). Le traitement du couple photogrammétrique passe par les étapes traditionnelles de l'orientation interne, relative et absolue. Par ailleurs les outils de manipulation d'images offerts par la plate-forme JAVA nous permettent de proposer divers développements (détection automatique des repères de fond de chambres ou de réseau, corrélation de points homologues) visant à automatiser le pointé de l'opérateur.

1 The uses of Object technologies

1.1 Object technologies and knowledge representation :

The strategy developed in Arpenteur, both in the photogrammetric development and in the architectural approach is directed by data-processing object languages in regards of formalization of knowledge complex fields.

The disciplines approached at each stage of the measuring process will be analyzed according to the postulate of reasoning by classification made possible by this object technology.

Natural History was the ground of predilection of the reasoning by classification since Antiquity. Aristotle provided alive beings classification system foundations, organized around the reproduction function, which has been taken again during the XVIIIth century by Linné and Buffon. The alive beings classification is old on a point of view of the universe to be classified. More exactly the classification of the alive beings proceeds in two stages :

- ✓ Conceptualization : the transfer from the proper name to the common noun,

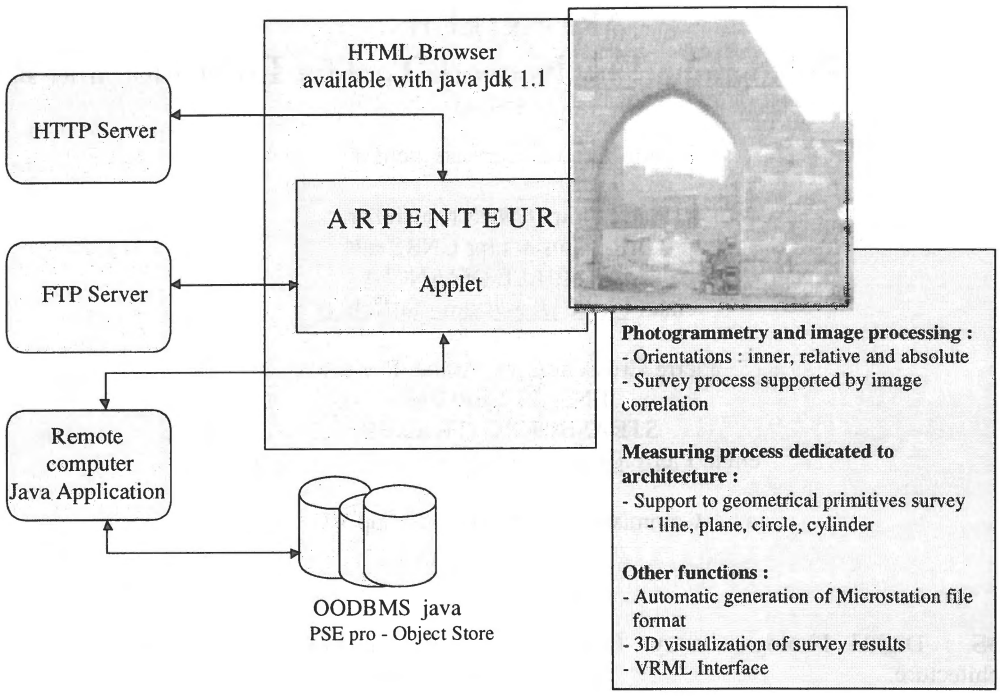

Figure 1. ARPENTEUR's project synoptic scheme.

- ✓ Organization of these concepts by properties factorization describing a certain point of view (ie. the class of the mammals factorizes a mode of reproduction). The species concept today is underlain by the description of the reproduction system.

The formalism object is to some extent the data-processing translation of the reasoning by classification. The universe of knowledge is discretized in elementary objects structured by specialization of properties. This approach makes it possible to model complex phenomena by the description of the relations between the various actors and this profits to us reaching high level of abstraction.

The object-oriented programming languages now give an opportunity to formalize and handle models of complex knowledge fields. The fields of knowledge are split into elementary concepts, structured through refinements of classes [Oussalah, 1997].

1.2 The Java environment

The programming language chosen is JAVA™. There is at least two reasons for this choice :

- ✓ Java is strongly object oriented.
- ✓ Java is a platform-independent programming language supposed to run anywhere, supported by a lot of internet browsers.

Java is a recent language, based on OAK developed by Grosling at SUN in 1991. OAK, was an object-oriented language, platform-independent. In 1995 OAK became JAVA by addition of internet capabilities. Java is given by SUN to internet community with its compiler, library, specifications and documentation.

1.2.1 The Java Virtual Machine

Once the code is written in Java, it has to be compiled in order to produce byte-code. This resulting code is a low level format and needs to be interpreted by each different hardware by the Java Virtual Machine. For each computer the Java Virtual Machine will be different that's why Java is platform independent.

1.3 The Model-View-Controller paradigm

Building a modular object-oriented user interface is a very hard task [Hunt, 1998]. The result is often very difficult to maintain, complex to understand and surely not reusable. However there is a lot of benefit to separate user interface from the application code. This kind of separation, in an object oriented context, is often made using Model-View-Controller method (MVC for short). The MVC, originated in Smalltalk, is used in many different contexts. Java, with it's event delegation model, allows us to use it in this application.

The advantage of this approach allows :

- ✓ A methodical approach of GUI design
- ✓ An independent development of application components (more than one programmer at the same time is possible)
- ✓ Reusability of application and user interface component
- ✓ Easy development of new features

In this context, independence between interface and model means that different interfaces can be used by the same application. This means that the application does not know which interface is currently connected to it. In the same idea any part of the system can be changed without causing trouble to the others.

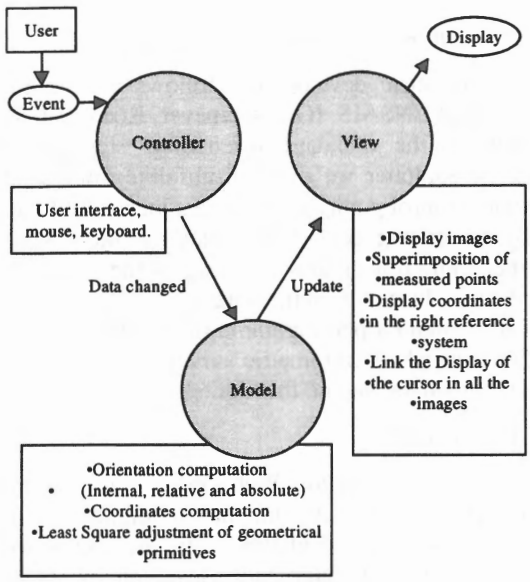

Figure 2. MVC synoptic scheme in Arpenteur.

1.4 The photogrammetric actors

The photogrammetric universe is modeled as an organization of concepts in different hierarchy and relationship to each other. In addition we have the three high hierarchies of the MVC system which allows the operator to navigate in the system.

In these conditions, writing a software is equivalent to describe relations between the different actors as for example : the photogrammetric model which knows his photography, which knows their camera, and so on.

2 A digital photogrammetric tool on the Web

The photogrammetric approach is based on the well known routines [Kraus, 97] used in TIPHON software [Grussenmeyer, Koehl, 1998]. The standard steps are developed : internal, relative and absolute orientation.
The Arpenteur is programmed in JAVA, using JDK 1.1.5 and is operational from any hardware platform supporting a web browser using this level of Java. Actually Arpenteur is tested with Netscape ™ Comunicator 4.05 on PC platform and Netscape Comunicator 4.03 running on SUN station.

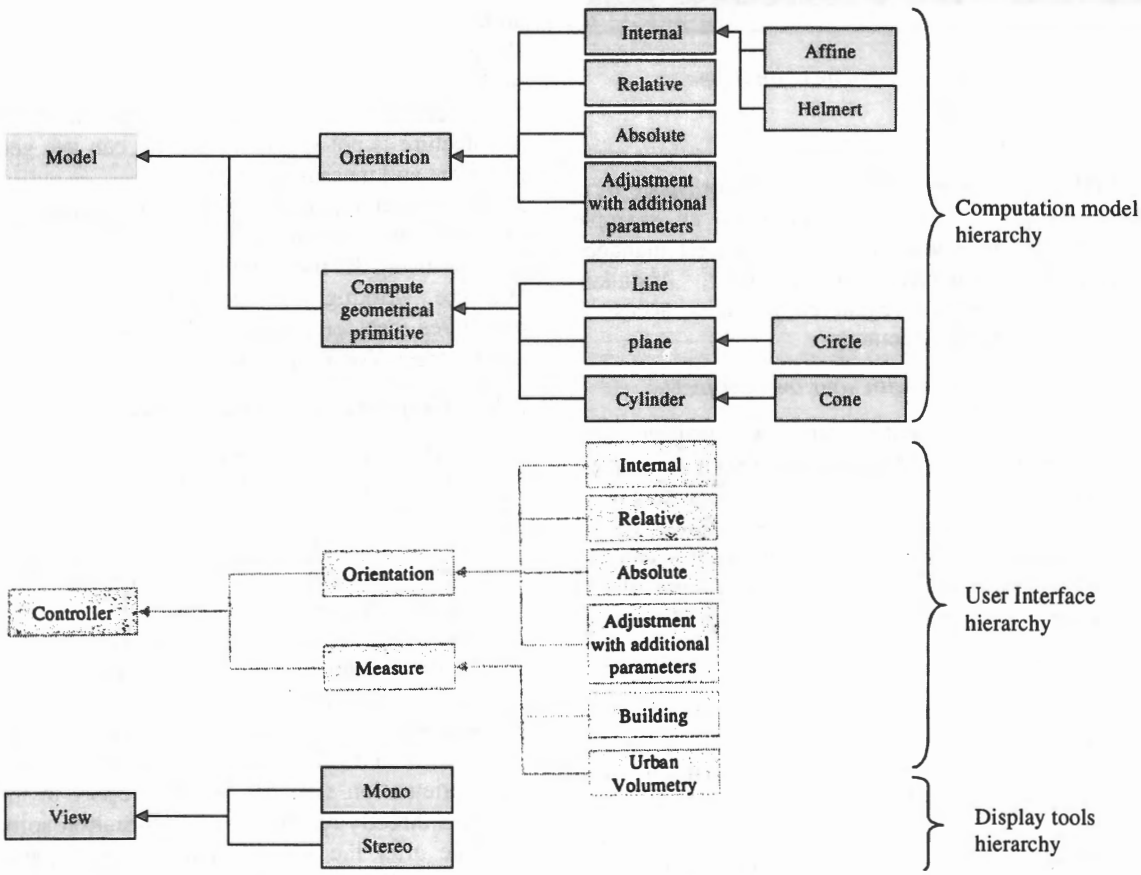

Figure 3. The hierarchy of the MVC actors.

2.1 *Internet Access*

Arpenteur is accessible via the internet network and web browser. We use three kinds of server to offer the service. Using Arpenteur means three steps :

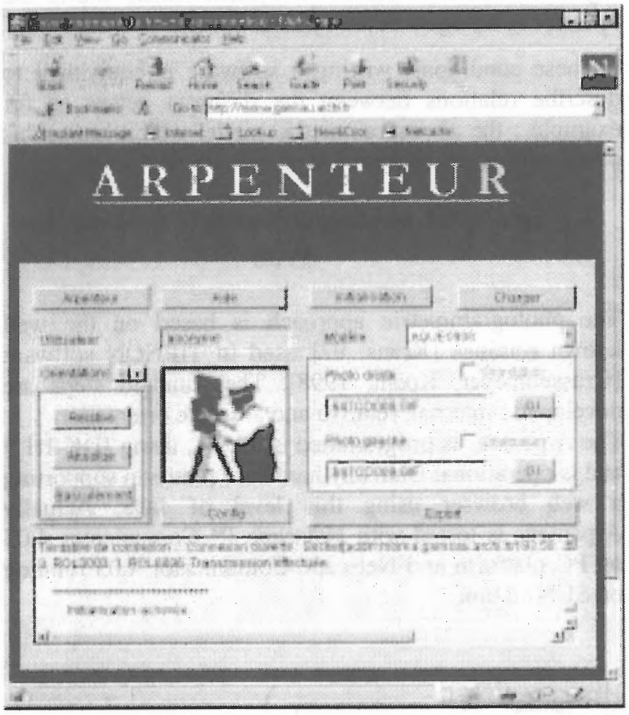

Figure 4. The Arpenteur main frame.

2.1.1 *Registration*

The HTTP server allows you to create a workspace by a registration page. You have an access to an example project made on an aqueduct in Cairo, project managed by Pierre Grussenmeyer [Grussenmeyer, Abdallah, 1997]. Once you are free registered you have access to the whole capability of Arpenteur.

2.1.2 *Using Arpenteur with your own project*

Of course you can create your own project with Arpenteur, you have a specific access to your workspace via an FTP server directly accessible through the main windows (Export button). The FTP server allows you to read a written file on your workspace, so you can put your images, camera definition file, ground point file on the server and get the output file generated by the system.

2.1.3 *Getting the results*

Arpenteur is an applet using a lot of Java classes. That means that the process is running on the client computer ; the Java security restrictions not allow an applet to write files on the client disk neither on the server disk. To solve this problem we develop a Java application server, running on the server machine and dedicated to saving files on disk. All the result files, as all orientations reports and plotting files, are written in your workspace by this Java application server after connection with the client.

2.2 *The photogrammetric functions*

2.2.1 *Orientations*

The photogrammetric development follows the Tiphon software made at ENSAIS, [Grussenmeyer, Koehl, 1998]. In addition of the standard orientation steps in a traditional stereoplotter we offer an absolute orientation made without control points. We define a local coordinate system by measuring particular points on the model, (plumb line, wall corner), and a scaling of the model by measuring some distances on the object.
The goal is to obtain a photogrammetric software easy to use, using a light photogrammetric survey (non-metric or partial-metric camera, and no theodolite).

2.2.2 *Measuring help*

Arpenteur is running on the Web. We try to use the digital aspect of the environment to minimize the inconvenient of web-distant platform. We use correlation in the inner orientation (automatic detection of reseau crosses) and also in homologous point measurement (during orientation steps or plotting). The subpixel correlation process is controlled by standard correlation factor [Kraus, 1997], [Grussenmeyer, Koehl, 1998].

2.2.3 *Geometrical tools*

In order to propose a photogrammetric tool dedicated to architecture, according to our last work ([Blaise, Drap, Florenzano, 1996], [Blaise, Drap, Florenzano, 1997]) we offer some geometrical tools to manage point measurement on geometrical primitive. In fact architecture is not geometry but we can use geometry to represent and measure architecture.
A set of different least square computation models are available like computation of line, plane, circle and cylinder using 3D measured points on their surface.
We are working on the extension of geometrical primitives (see for example the work of Henri Veldhuis and Georges Vosselman [Veldhuis, Vosselman, 98]).

2.3 *Graphical and textual output results*

The result of all orientation steps are reported in ASCII files. Therefore it's often difficult to have a good visualization of numerical result just looking at column numbers. In addition we need to save and represent 3D data generated by the stereoplotting phase after orientations. We use the 3D file format of MicroStation application (made by Bentley ™). This file format was originally developed by Intergraph company and is particularly well fit for 3D geometrical representation. We developed a set of routines able to write geometrical information in this file format. [1]
Each orientation step can write a report in this format which is directly readable by MicroStation software. For example after the inner orientation of a partial metric camera image, as Rollei 3003, the system generates

[1] *This was done with Gilles Gaillard, SETP (Société, d'Etudes et de Travaux Photogrammétriques Salon de Provence, FRANCE)*

automatically a MicroStation file which represents the discrepancies between theoretical value of the reseau and measuring crosses. An anamorphosis factor is computed to represent the discrepancies as visible vectors.

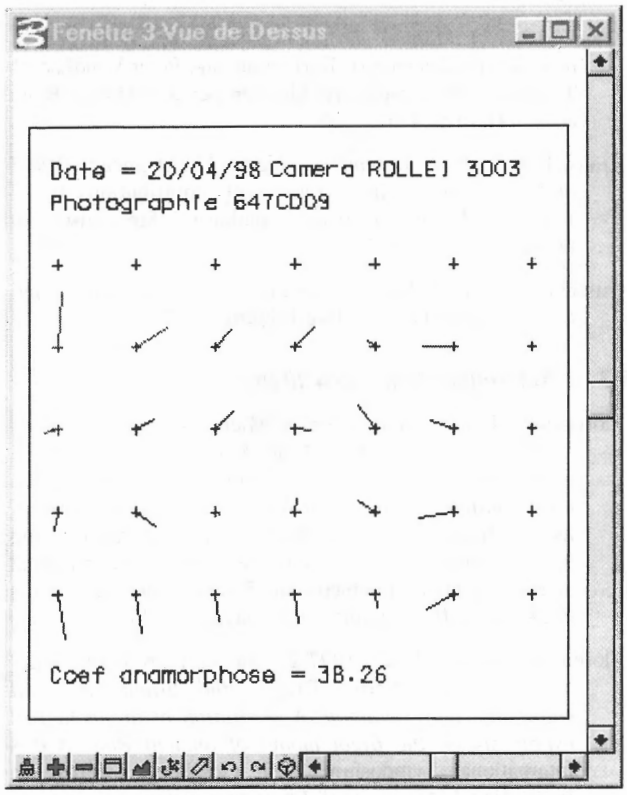

Figure 5. Automatic report of reseau deformations in MicroStation file format

These files are generated during the inner orientation validation and named with the photography name and a standard suffix used in Microstation (.dgn).

3 Java and Internet : Inconvenients and problems

The use of Java and Web platform is full of advantage and promises. Distributing software on any platform, in any place connected to Internet, reducing updating version, is of course very interesting but presently yet confidential for sharp applications.
We can isolate three delicate points in distributing Arpenteur through Internet :

3.1 Loading time

This software architecture is based on client-server relation : the software run on the client computer after it was loading through the network. The loading time can be important, the software itself is a large file and of course it depends also of the image size.
In addition the data rate flow on the network is not regular. Therefore once the files and images are loaded in the remote computer the use of disk cache allows to work properly.

3.2 Unstability of programming language

Java is a recent language, in constant updating. We choose to work with the latest version (actually JDK 1.1.5) but this position carries out some problems :

- ✓ The compiler is not stable and we've to develop in spite of a lot of bugs.
- ✓ We don't know on which Web browser the applet will run, and usually most of browsers have one or two version of the Java Virtual Machine late. Using the latest version of Java means that a very reduce number of people connected can use our job. This looks like in contradiction with the goal : a large public access. We bet on future development of Java and it's diffusion around Internet.
- ✓ In the same idea, all the Java Virtual Machine are not at the same level, so it's actually possible that some features don't work on certain platform.

3.3 Time of execution

The Java is compiled in byte-code then interpreted by the Virtual Machine. This allows multiple computer running the same software but increase the execution time. Presently executing a software in Java takes 10 or 20 more time than in C++ native code.
This become a problem for big operation, like image processing. Once again we think that this situation will change in one or two years.

4 Perspectives : a photogrammetric tool dedicated to architecture

The Arpenteur project is young, the development started in November 1997 and now just a light version of a standard photogrammetric process is available. We organize our work on two directions :

- ✓ Increase the photogrammetric tools, in reliability and interface user-friendliness.
- ✓ The realization of a tool dedicated to architectural survey.

4.1 The photogrammetric software

We are working on increasing the photogrammetric software performances, the didactical reports, the speed of algorithm and the other features development like working on normalized images.

4.2 A tool dedicated to architectural survey

The plotting module will be dedicated to architecture. It is based on a formalization of architectural and geometrical knowledge. The architectural corpus must be identified and structured, the architectural knowledge is used to guide and control the measuring process of a building. This means that the morphology of the measured object is already known [Blaise, Drap, Florenzano, 1996], [Blaise, Drap, Florenzano, 1997].
Elements of a building will be described as "entities" (elementary elements) [Ginouvès, 1992] providing that they meet two requirements :

- ✓ An entity is a unique " object " identified by a single element of the architectural vocabulary.
- ✓ An entity has an obvious and permanent role in the physical structure of the building.

This takes place at several levels :

- ✓ Once the architectural entity is identified, a panel of pertinent geometric primitives will be proposed.
- ✓ After some measures are done for each of primitives, the system will automatically go on new points and then dynamically adjust the primitive.

The benefit of a tight link between knowledge and measure will appear on several levels :

- ✓ The survey process of architectural entities can be drastically simplified, if desired, and limited to quick control of the underlying model.
- ✓ The photogrammetric tool allows both to validate a structural architectural model and to study any surface alteration.

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