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TEACHING ARCHITECTURAL PHOTOGRAMMETRY ON THE WEB WITH ARPENTEUR

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ABSTRACT

The paper presents the main features of a digital photogrammetry software package running on the web, and its use for teaching photogrammetry. The network tool is called ARPENTEUR (Architectural PhotogrammEtry Network Tool for EdUcation and Research). Everybody can freely access ARPENTEUR via the internet (<http://www.arpenteur.net>). This software is an extension of the TIPHON software (Traitement d'Images et PHOtogrammÉtrie Numérique) which has been developed with the students of the Department of Surveying at ENSAIS-LERGEC (Engineering College of the Polytechnicum of Strasbourg) since 1996. Since 1998, in the frame of a joint project between ENSAIS-LERGEC and GAMSAU (laboratory of the French National Science Council located at the school of Architecture at Marseilles, France), the TIPHON software has been adapted to the Internet World to become platform-independent and available as an applet on the web by a simple internet browser like NetscapeTM Communicator. The software package is a Web based tool since photogrammetric concepts are embedded in Web technology and JavaTM programming language. Different solutions are available for the orientation of the digital images. Images from different kinds of cameras (with fiducial marks, *réseau* cameras, non metric and digital cameras) can be used. The *réseau* crosses are measured automatically in the interior orientation. The measurements on the images are manual or semiautomatic by area based correlation. The model resulting from the survey process can be visualized either on the internet-oriented VRML plug-ins, or inside the MicrostationTM software package. Presently various examples from different projects mainly based on small and medium format images are accessible via the world wide web on our servers located in Marseilles and Strasbourg (France). The aim of the paper is :

- to present shortly our concept of running photogrammetric software on the Internet by a simple browser;
- to explain how users can handle examples usable for teaching architectural photogrammetry on the web (available at www.arpenteur.net, user : isprs password: amsterdam) and set their personal projects on the web with ARPENTEUR.

RESUME

L'article présente les caractéristiques principales d'un logiciel de photogrammétrie numérique fonctionnant sur Internet. Le logiciel, qui est dédié à la photogrammétrie architecturale, s'appelle ARPENTEUR (Architectural PhotogrammEtry Network Tool for EdUcation and Research). Tout utilisateur peut librement accéder à ARPENTEUR par l'intermédiaire d'Internet (<http://www.arpenteur.net>). Ce logiciel est une extension du logiciel TIPHON (Traitement d'Images et PHOtogrammÉtrie Numérique) qui avait été développé avec les étudiants de la Filière Topographie de l'ENSAIS-LERGEC (Ecole Nationale Supérieure des Arts et Industries du Polytechnicum de Strasbourg) depuis 1996. Depuis 1998, dans le cadre d'un projet commun entre l'ENSAIS-LERGEC et le GAMSAU (laboratoire du CNRS implanté au sein de l'Ecole d'Architecture de Marseille), le logiciel TIPHON a été réécrit sous la forme d'applets pour être intégré à Internet et devenir indépendant des systèmes d'exploitation. Un simple navigateur comme NetscapeTM Communicator permet d'utiliser le logiciel sur le Web. Le logiciel est un véritable outil Internet puisque les concepts photogrammétriques développés en JavaTM intègrent les dernières technologies d'Internet. Différentes solutions sont disponibles pour le calcul des orientations des images numériques. Différents types d'images (avec marques-repères, avec réseau, non métriques et numériques) peuvent être utilisées. Les croix de réseau sont mesurées automatiquement lors de l'orientation interne. Les mesures sur les images sont manuelles ou semi-automatiques par corrélation. Les résultats des traitements peuvent être visualisés soit en VRML, soit à l'aide du logiciel MicrostationTM. Des exemples de différents projets constitués d'images de petits ou de moyens formats sont accessibles par Internet sur nos serveurs situés à Marseille et Strasbourg (France). Le but de cet article est:

- de présenter brièvement notre concept de photogrammétrie sur Internet;
- d'expliquer comment utiliser les exemples disponibles pour l'enseignement de la photogrammétrie architecturale (accessibles à l'adresse www.arpenteur.net, user : isprs password: amsterdam) et préparer ses projets personnels sur Internet avec ARPENTEUR.

1 INTRODUCTION

Computer assisted methods are more and more developed in education and new technologies are used enthusiastically by students. Different approaches as well as techniques are available: educational course information system, e-mail, electronic lecture materials in Internet or on CD/diskette, computer assisted lecturing, computer assisted exercises and distance learning (Artimo, 1998) & (Höhle, 1998). Photogrammetric software packages are usually WindowsTM or UnixTM based applications which are usually installed separately on individual computers. For each update, a new installation is required on each computer. For software packages available as applets on the Internet, the updating is done directly on the server and the user always works with the latest release available by simple browser like NetscapeTM Communicator. We discuss in this paper about digital photogrammetry by the use of such a Web-based tool called ARPENTEUR (as ARchitectural PhotogrammEtry Network Tool for EdUcation and Research).

ARPENTEUR (Drap & Grussenmeyer, 2000) take an interest in teaching photogrammetry because it can be easily used from anywhere all over the world and with whatever operating system. As the applet is based on client-server relation, the software package is loaded through the network and runs on the client computer.

In this paper, the management of a project as well as the description of an example of photogrammetric model based on small format images is described.

2 WEB-BASED PHOTOGRAMMETRY WITH ARPENTEUR

2.1 Chronology of ARPENTEUR

ARPENTEUR is the extension of a WindowsTM application called TIPHON (as 'Traitement d'Images et PHOtogrammÉtrie Numérique') which has been developed since 1996 at the Departement of Surveying at ENSAIS-LERGECE Strasbourg. A first prototype of our web based tool has been presented at the ISPRS Comm. V Symposium in Hakodate (Drap & Grussenmeyer, 1998).

The aim of this project conducted by two French Research groups located in Marseilles (GAMSAU laboratory of the French National Science Council, located in the School of Architecture) and in Strasbourg (Photogrammetry and Geomatics group at ENSAIS-LERGECE) is to develop a digital photogrammetric workstation on the Web and a tool dedicated to architectural survey.

ARPENTEUR is developed in Java which incorporates some of the most powerful new concepts in computer language design. Java is a recent language in constant updating. At the moment (March 2000) we are using the JDK 1.1.8 (Java Development Kit). Our tool is operational from any hardware platform supporting a Web browser using this Java level.

2.2 Connection to the ARPENTEUR servers: www.arpenteur.net

The packages required on the computer are NetscapeTM Communicator 4.51 on PC and NetscapeTM Communicator 4.6 on SUNTM workstations, as well as CosmoplayerTM 2.1 as an additional VRML plug-in for the visualization of models. This plug-in is not required if ARPENTEUR is just used for teaching the orientation of photogrammetric models. A Java visualization tool in under development and should avoid in the future the installation of the plug-in.

We would like to inform users that a regular data flow on the Internet is required and that the loading time can be important because the software package and the image files are loaded through the network during the client-server relation. However once the files and images are loaded in the remote computer, the work is possible by the use of the disk cache. The use of private Internet connections with 56K modems is of course not suited. We are convinced that present limits of data flow will be overrun in the future by the coming Web Technology.

2.3 Using examples on the servers

By selecting the Web address www.arpenteur.net, the user will have the choice to start ARPENTEUR on one of the two servers located in Strasbourg or Marseilles. User name and password are required to have an access to personal projects. By an anonymous login, all users will have access to different projects. By creating an own project, a directory will be created on the server and examples will be copied in the user's folder. Personal projects (images, control point and camera files) can be up- and-downloaded on the server by FTP (see §3.5).

The example described later (model : *citadel_strasbg*) is available by selecting: user: *isprs* password: *amsterdam*). It is also copied in the personal folder by creating a new user in ARPENTEUR.

3 PROJECT MANAGEMENT

3.1 ARPENTEUR's main frame

By starting the software package through the browser, the main frame of ARPENTEUR (figure 1) is loaded. The main frame is divided into four parts :

1. The model management window allows:
 - the selection of an existing model in the current folder defined by the user's name;
 - the loading of the data files and images in the remote computer.
2. The management of the orientation and measure process; the user can:
 - realize the different steps of the orientation (see § 3.3);
 - select a modeling module once the orientation is done.
3. The 'System' window is used:
 - to configure Arpenteur (e.g. correlation matrix), show results, create new models;
 - to up-and-download files between the server and the client;
 - to visualize data in a 3D viewer.
4. A window to display messages and events corresponding to the use of the software package

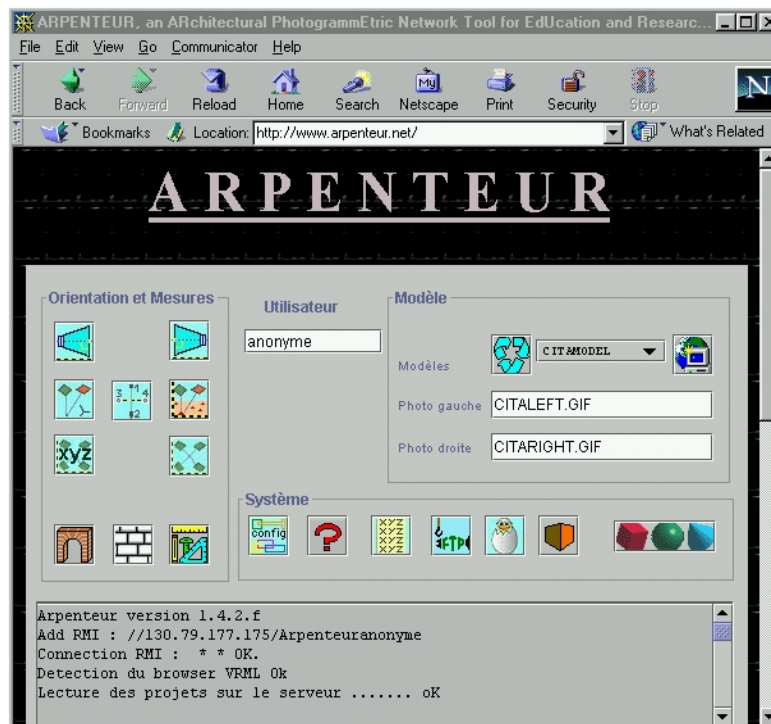


Figure 1. ARPENTEUR main frame available at <http://www.arpenteur.net>

3.2 Select an existing model



Select the available models in the user's folder



Load the selected model

Figure 2. Selection of a model in ARPENTEUR

3.3 Orientation and measure

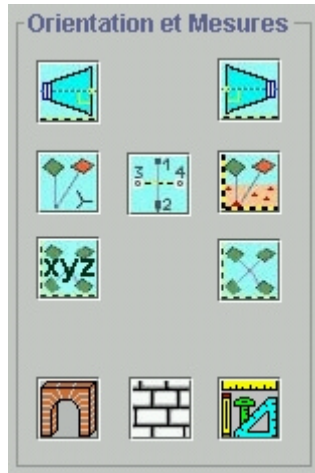


Figure 3. Orientation and measure window



Interior orientation (left image of the model)



Interior orientation (right image of the model)



Relative orientation of the model



Absolute orientation of the model



Absolute orientation based on distances and vertical lines



Control point and tie point measurement in preparation for the bundle adjustment



Computation of the bundle adjustment (two or more images of a project)



Module for simple measurements (points, distances ...)



Measurement process based on stone by stone surveying (architectural modeling), see an example in (Drap et al., 2000)



Measurement process based on formalization of architectural and geometrical knowledge, see an example in (Drap et al., 1999)

3.4 Configuration and system management

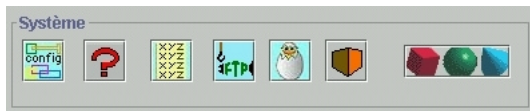


Figure 4: Configuration and system management in ARPENTEUR



Configuration (correlation matrix, colors...)



Help



Results of the orientation process (html)



Specific access to the user's workspace by FTP (File Transfer Protocol), to up and download files.



Creation of a new model



3D viewer (developed in Java™ within Arpenteur)



3D viewer (visualization in Cosmoplayer™ and generation of VRML)

3.5 Model definition

The user can work on his own project and has a specific access to his workspace via FTP server. The FTP server allows to read files saved in the user's workspace, to put images (only GIF or JPG images limited to 2MB), camera files and control point files on the server, and to get the result files generated by the system. Files are stored in different subdirectories ("calage, camera, images, modeles, results") corresponding to the user's project. Examples of files can be downloaded via FTP server. For the creation of a new model, following files are required:

- control point file;
- camera file;
- GIF or JPEG images (limited to 2Mb).

4 OVERVIEW OF THE PHOTOGRAMMETRIC SOLUTIONS AVAILABLE IN ARPENTEUR

The photogrammetric development follows the TIPHON software developed at ENSAIS (Grussenmeyer, 1998). An overview of the various photogrammetric applications available at present is given in figure 6.

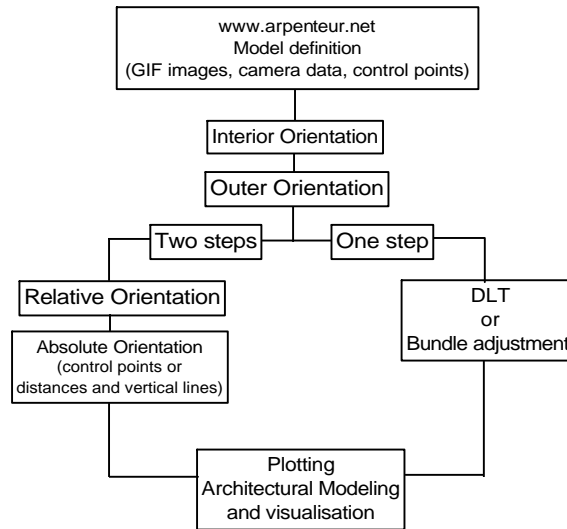


Figure 6. Photogrammetric solutions available in ARPENTEUR

4.1 Correlation

In digital photogrammetry most of the measurements can be done automatically by correlation. The task is to find the position of a geometric figure in a digital image (Kraus, 1994). Area based correlation computations are used to determine the required position in the digital image. The used method is a combination of the maximum correlation coefficient and correlation in the subpixel range. In ARPENTEUR, image correlation is used for point measurement in the interior orientation (e.g. automatic measurement of *réseau* crosses) and also for the measurement of homologous points (during the outer orientation and the plotting process).

The size of the reference and search matrix can be defined by the user (12x12 pixels by default) in the configuration module.

4.2 Image editing

By clicking on the right button of the mouse, the user is allowed (for each displayed image):

- to zoom in & out;
- to handle an image editor for extracting image parts;
- to enhance the image (brightness, color to B/W, etc.).

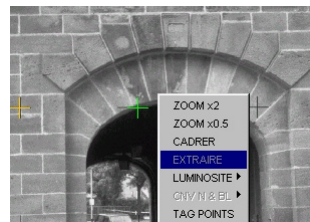


Figure 7. Image editing

4.3 Interior orientation

ARPENTEUR can handle different kinds of digital images equipped or not with fiducial marks or *réseau*, or more generally photos from point and shot digital cameras. Camera parameters are stored in a separate text file. The calibration has to be done separately with other software (e.g. with the camera calibrator module of Photomodeler™).

The required parameters are:

- number of fiducial informations (marks, crosses, corners);
- co-ordinates of the fiducial marks, or *réseau*, or corners (non-metric images), or chip size (digital camera);
- co-ordinates of the principal point;
- calibrated focal length;
- distortion curve (table of the radial distortion).

An affine transformation is used to compute the photo co-ordinates. For the *réseau* measurement, the user can define artificially in a table a cross from the grey values (configuration module). The *réseau* crosses (figure 8) can then be found automatically. For the inner orientation of digital images, the four corners are located automatically and the user has just to define the size of the chip (four co-ordinates of the corners) in the camera file.

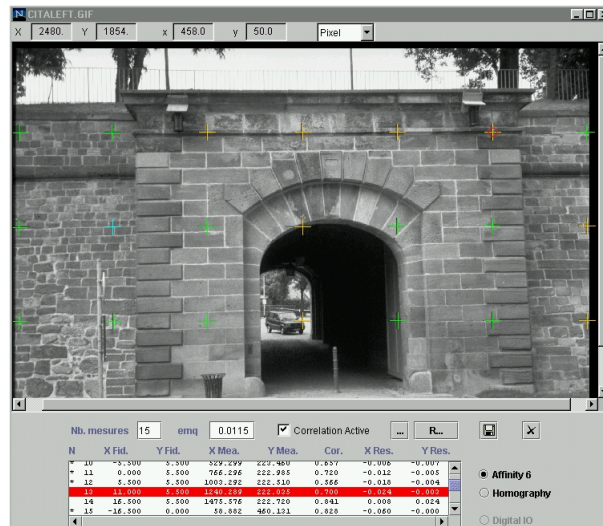


Figure 8. the dialogue box of the inner orientation.

The crosses represent the correlation on the *réseau* (in this example a RolleiMetric35 image)
 Different colors of the crosses correspond to active or non-active or bad-correlated crosses.

4.4 Outer orientation

4.4.1 Two-step orientation

Two-step orientation process is based on relative and absolute orientations which are well known on analytical or digital stereo-plotters.



For the relative orientation (figure 9), the measure of homologous points is achieved manually or semi-automatically by correlation such as :

- a point or an area is chosen in the left (or right) image;
- the homologous point or area is approximately indicated on the other image;
- the final point is computed by correlation.

The relative orientation of independent photo pairs is based on the coplanarity condition (Albertz, 1989). The definition of the approximate orientation elements is made possible by the user in a dialogue box.



The model is afterwards computed to complete the absolute orientation (figure 10) by spatial similarity transformation based on control points defined by their co-ordinates given in a text file. The user can specify approximated co-ordinates for the adjustment.



In addition to the standard orientation steps, we also propose an absolute orientation made without control points. We define a local co-ordinate system by measuring particular points on the model (vertical lines, wall corners), and scaling of the model by measuring distances on the object. The goal is to provide an easy-to-use photogrammetric software package, allowing also simple surveys with non-metric cameras and without theodolite.



Figure 9. Relative orientation with ARPENTEUR

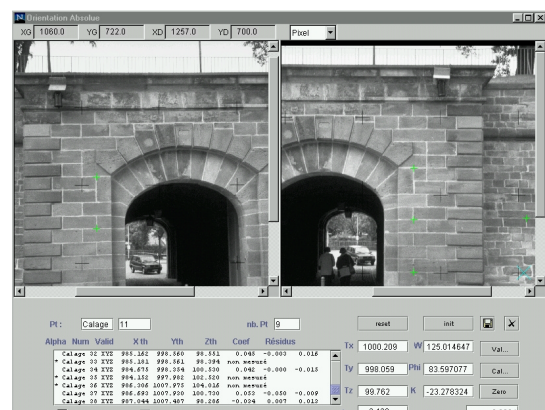
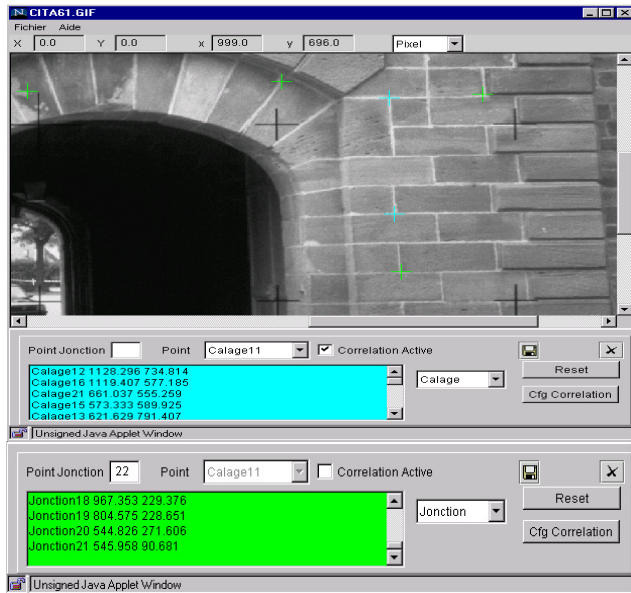


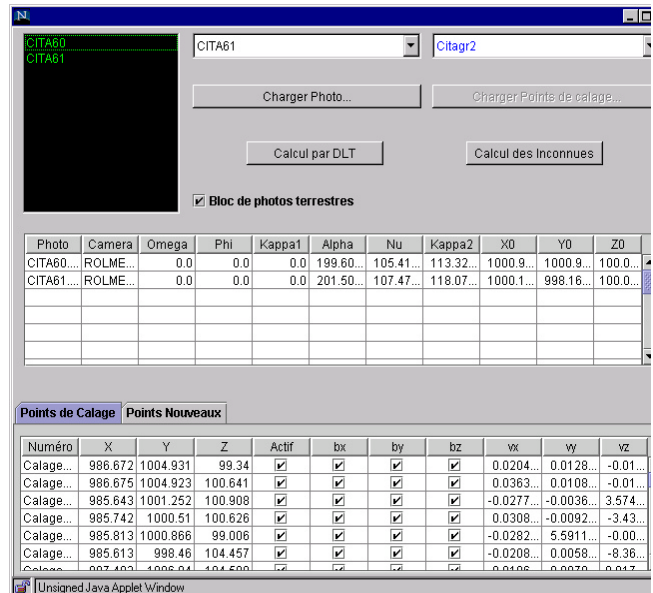
Figure 10. Absolute orientation with ARPENTEUR

4.4.2 One-step orientation

All measured points can be matched in a bundle adjustment. The initial approximate values of the adjustment (camera rotations and co-ordinates of the center of perspective) can be achieved by a Direct Linear Transformation if at least six control points are already measured in the images. This solution is also appropriate for convergent photos. The control and tie points are measured (figure 11a) by image pairs. The bundle acquisition module allows to find easily the previous measured points (available for correlation). The set of images (usually more than two in a project) is afterwards computed separately in a block adjustment (figure 11b).



Control point and tie point measurements



DLT and Bundle block adjustment



Figures 11a & b. One step orientation in ARPENTEUR



5 MODELING

Different modeling tools have been developed for research purposes in the frame of ARPENTEUR. A measurement process based on formalization of architectural and geometrical knowledge for the survey of geometrical primitives of architectural elements has been presented at the last CIPA symposium (Drap et al., 1999).

Another example of stone-by-stone surveying (Drap et al., 2000) is shown in figure 12. A previous analysis of the edifice is conducted by an archaeologist to define the characteristics and the chronology of the construction, and the properties of all the measured architectural entities. This results in the definition of an approximate depth for each type of stone, allowing a survey limited to the block's visible part. An extrusion vector is then computed to complete the geometrical description of the stone blocks. A polyhedron representation of the object morphology follows the block measurements. 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. The tool creates a direct link between the architectural object and the database.

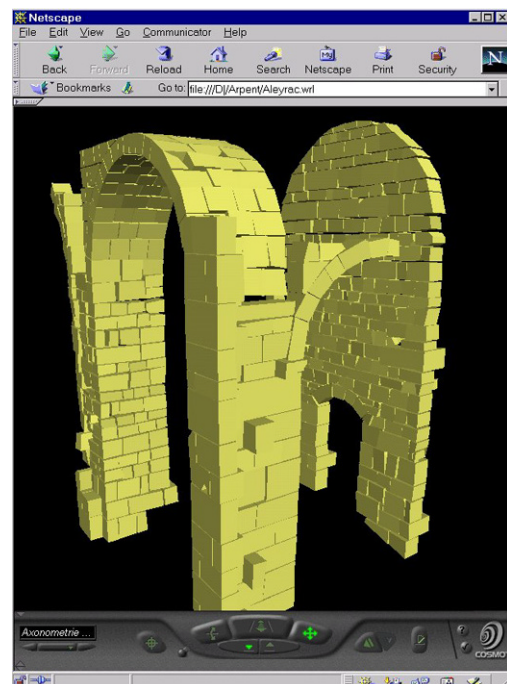


Figure 12. Measurement process based on stone-by-stone survey.

6 CONCLUSION

The concept of web-based photogrammetry and the use of software packages from anywhere all over the world is very exciting and in constant updating. However, there are still some limits due to irregular data transfer on Internet. The loading time can be important for large files as the software itself or the image files. There is no longer any doubt about these limitations because new network tools with high data transfer looks promising. At the present time, our software package is operational with small format images (temporarily limited to 2 Mb) and various applications in architectural photogrammetry have been tested. Since models have been prepared on the ARPENTEUR servers, the use for teaching either the orientation of photogrammetric models or the modeling of architecture has been possible.

ARPENTEUR follows the objectives of the International Scientific Committee for Documentation and Architectural Photogrammetry (CIPA), by proposing simple methods for architectural photogrammetry (CIPA WG3). The development of a database containing different examples of architectural photogrammetry projects can be a further objective in the frame of international cooperation.

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