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3D BUILDING MODEL AS AN INTERFACE FOR A WEB INFORMATION SYSTEM CASE STUDY OF THE PONTONNIERS HIGH SCHOOL IN STRASBOURG

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ABSTRACT:

The paper presents the results of a test study based on 3D modelling of the “Pontonniers International high school in Strasbourg” where the Alsace Region Institution asked for building documentation in order to proceed to a complete diagnosis to conform to the current regulation (detection of asbestos and lead, fire safety, heating systems, electricity, accessibility, etc.) as well as to insure the future of the patrimony and among other the general maintenance of roofs and facades.

The diagnosis and statements campaigns are usually based on maps and photos, which are used to locate damaged elements. However, aware of the possibilities offered by photogrammetric techniques, we found it interesting to integrate these methods in the diagnosis process. A 3D model of the buildings of the site seems essential for further analysis and studies, providing georeferenced data for the user and visualisation in order to know the state of the buildings and to planify the management of works. The link with a database describing the patrimony’s referential will be used to find existing maps, overall photos as well as zooms on details and other alphanumeric data, by browsing in the 3D model.

To build a consistent geometric 3D model, we use on one side architectural information of the building, and on the other side dimensional data. Architectural knowledge based on analysis and overall documents leads the drawing of the model, without any scale in this first step. Only the shapes and the completeness of the model are aimed at this stage. To reach this goal, the Sketchup software package dedicated for designing buildings has been used. The integration of dimensional data is only done in a second stage, based on former geometric elements defined as specifications of the architectural knowledge. The scaling of the model is thus not dependent on the used techniques which can be surveying, photogrammetry or lasergrammetry. VRML textured models of the buildings result from this process. For the textures, orthophotos previously prepared for the companies in charge of the diagnosis are used.

This 3D model is used as a browsing interface in the Information System of the Pontonniers high school in Strasbourg for handling all the available data. For the managers of the site, the model will also be used to modify and update the database. From a technical point of view, this information system is based on an EasyPHP server, allowing the creation of databases in MySQL, and interaction between the databases within PHP software packages. The 3D model is described in VRML, mostly used for the visualisation of 3D scenes on the Web. The realisation of the 3D model is prior to any following step. An anchor is defined for each face, which helps for its identification and its interaction. Any face of the model can thus be accessed, by consultation or in order to modify the corresponding tables in the MySQL database.

All architectural data described above will be integrated in the overall database of the Region Alsace Institution for the management of the high schools of the Region. The interfaced 3D model can thus be used to reach any type of information from this database (as for example annual payment, representatives, cadastral data, companies, safety, etc.) by PHP software packages written to generate HTML pages. The update of the database is therefore possible directly from browsing in the 3D building models.

1. INTRODUCTION

Public buildings management involves to set up methods of running and to follow through the operations assuring the knowledge of buildings and equipment, of its condition and the control of claims and interventions. In the frame of an order of the Alsace Region Institution in charge of 77 high schools of the Region, a test study based on 3D modelling of the “Pontonniers International high school” in Strasbourg (a site with typical buildings from the 18th century) has been conducted. The different steps starting from documentation,

mapping and imaging, 3D modelling till 3D Information Systems for Built Heritage management for this well known site (fig. 1) in Strasbourg are presented in the paper. Photogrammetric techniques (orthophotos and 3D models) have been introduced to companies in charge of the diagnosis of the buildings.

The working and the management of a building induce the creation of a large quantity of information that have to be indexed and recorded in databases. To be able to derive benefit from this registered data and to use it for future work, it is then necessary to carry out an information system. It makes the

information interpretable and permits also its enrichment by the immediate confrontation of all types of data at disposal.



Fig. 1. Aerial view of "Pontonniers International High School" area in Strasbourg

The majority of information systems that are created nowadays, notably in the local and regional institutions are Geographical Information Systems (GIS). They allow the confrontation of geolocalised data at a large scale. Their principal characteristics are usually:

- a computer system that records (thanks to the associate database) and uses geographical data regarding objects located on, above or under the earth surface;
- a system that assists the analysis, the management and the visualisation of spatial data;
- a system that helps the interpreting, the integration and the investigation of spatial objects to assist the decision-taking.

The same characteristics are of course transposable for an information system, which would allow managing any other type of data than geographical ones. In fact, the principle of "information system" is usable for the management of databases containing very heterogeneous data types, such as historical, topographical, architectural, financial, photographic or textual ones. The quality of an information system depends on its capacity to present data in an effective, fast and educational way. It has to simplify the extraction of the best possible information for the system user and it has to make this information available for interpretative studies.

We have chosen to carry out an information system for the Pontonniers International High School of Strasbourg, in which data concerning the high school management are reachable through three-dimensional representations of the building. Our system is not a pure Geographical Information System (since we integrate very diverse types of data), but the information search is done in a localised way via the 3D model of the buildings. The 3D representation serves as an access interface to the data. For the administrators of the high school and future users of the system, it will also serve as an interface for the modification and the updating of the recorded information. The system has been developed to be available through the Internet by many users. It works independently of any commercial software, and in a simple and clear way, both for the consultation and for the modification of information. The database done includes information concerning several high schools, and it will be sufficient to model these buildings (and to make these models interactive) in order to access to this data in the same way than for the prototype.

Interesting examples of web information systems for the Built Heritage are presented in (Zlatanova & Gruber,1998), (Drap et al., 2001), (Blaise et al., 2004), (Dudek et al., 2004). Technical details regarding the computer architecture of web information systems are given in (Leukert et al., 2000).

2. DOCUMENTATION

Region Alsace Institution is convinced that an interactive 3D textured model of the site linked to a database is full of interest for the managers and users of the system, as well as for the management of knowledge and equipment of buildings, control of claims and interventions.

This test study is important for the Institution as it is aimed to be generalized for all the 77 High Schools of the Alsace Region. The work should thus be presented and described in details (for both technical and economical point of views) in order to prepare future tenders for architects or surveyors. Simplification of 3D models is an important matter for this project, since low-cost models are expected.

The duration of field work must be as short as possible as access to high schools is not possible during school periods. Fast techniques as photogrammetry or laserscanning are thus recommended.

Formats defined in the specifications are VRML for models and AutoCAD© (DWG) for maps. Calibrated cameras are required for the documentation of the buildings (façades and roofs) to allow the photos to be used for photogrammetric purposes.

As no laserscanner was available at the begin of the project, multi-image photogrammetry techniques as presented in (Grussenmeyer et al., 2002) have been applied. Canon EOS 5D camera (4368 x 2912 pixels) with different calibrated objectives has been used, and control points on the façades have been measured by reflectorless totalstation.

In addition, aerial digital images (4080 x 4076 pixels) from 2004 were available (overview in fig. 1). In relation with the company in charge of the diagnosis of the external parts of the building, we had the opportunity to make photos from an aerial work platform, as complement to those taken from ground level. Photomodeler 5 has been used to orient all the images (fig. 2) thanks to control points located around the site and in the inner courtyard.

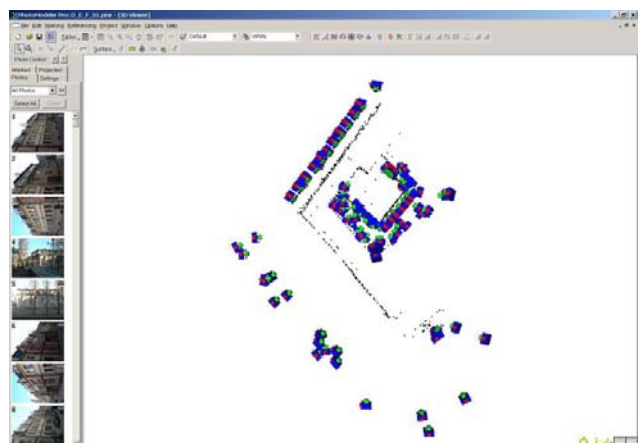


Fig. 2. Overall view of the photo stations around the site

No photomodel has not been produced with this software, but only 3D geometric points (fig. 3) and orthophotos of the façades (fig.4).

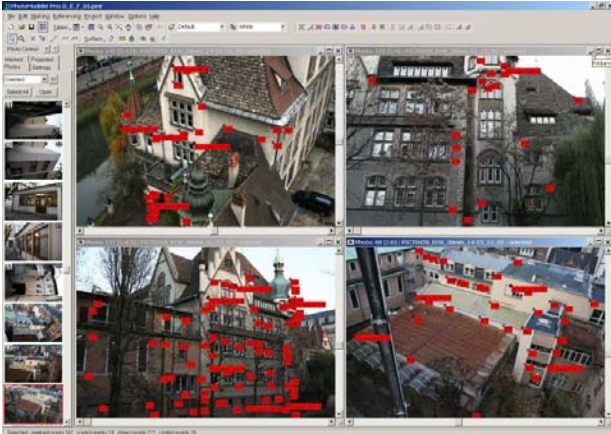


Fig. 3. Set of photos of Pontonniers' project in PhotoModeler 5 user interface.

No detailed plotting were required because this kind of work is time consuming and expensive. Plottings are currently replaced by orthophotos which can be easily imported in AutoCAD® (fig. 4). In this software, each company can work in specific layers for the drawing of the details of their diagnosis.



Fig. 4. Example of orthophoto (Building C) imported into AutoCAD® software and used as reference documentation for all providers.

3. 3D MODELING OF BUILDINGS

3.1 Modeling principles used in this project

To model the buildings we use the analogy of shapes with respect to geometry. We set up in first stage information to include in the geometric model, describe afterwards the elements to model and finally define a way to arrange these elements. Geometry connects with two independent concepts: the relation between the elements of the model and their dimensions.

If we consider data acquisition from the dimensional point of view, position of objects measured in space depend on the used technique. In architectural photogrammetry, we choose the point to measure in the image whereas in laserscanning the object is defined from the point density of the cloud point. The

analogy shape/geometry finally depends on the number of measured points. Elements to be modelled are organized according to their position in 3D space. The consequence of this approach based only on positioning methods is that elements which are not measured are not modelled. Usually, for technical and optical reasons, 3D acquisition techniques do not allow to measure all details of built work. The complete geometry is thus not available.

The relational approach of geometry aims to define elements of the model regarding their relations. Effective dimensions of these elements are deduced from the defined relations. We don't consider here absolute dimensions but dimensions depending of the own scale of the model. A model built with respect to relations of its elements is more consistent as it depends of the definition of its elements and not of the capacity of an instrument to measure its position. The definition of relations between geometric elements requires rules based on hypothesis set up on the object to model.

3.2 Architectural work

We consider architectural work as the object to survey. This work is a result of the use of several knowledge, as for example architectural arrangement, construction and materials. This knowledge is part of architectural information which can be divided in two types:

- analytical information: an existing building contains its knowledge which is retrievable by analysis and research. This information is the result of investigation and logic design. This interpretation work is a chain of reasoning of the external part of built works. This decomposition can be a thematic one : volumetric analysis (floors and elements of buildings), stylistic study, structural study for example;
- global documentation: this documentation is based on sets of thematic elements. We can consider treatises, methods, glossaries, indexes,. The book of (Pérouse de Montclos, 1993) is a good example of this type of documentation with a method of description of architectural heritage. It deals with vocabulary of architectural elements and corresponding illustrations. It is based on a large set of books as for example a descriptive catalogue of French Architecture (11th to 16th centuries) of Eugène Viollet-le-Duc. Another reference is the Dicobat (Vigan, 1992) used by contemporary architects. Words from the past are still in use in architecture today and there is no breaking in the constructive tradition.

3.3 Combination of dimensional and architectural information

To manage the construction of a consistent geometric model of architectural work, we use both architectural information and dimensional data. Combination of both information can avoid deficiencies due to separate use of each method:

- architectural knowledge: analytical as well as documentary knowledge allow the set up of elements of the geometric model. Architectural knowledge is a guide and assistance in the working out of the model. In a first step, the resulted model is not scaled but faithful to the original object, considering its shape and completeness;
- dimensional documentation: we initiate the integration of dimensional data from the model defined by its architectural knowledge. Elements defined by their

geometry are used for the segmentation of measured data. The complete but unscaled model is thus considered as a tender document with respect to dimensional data. Combination of two types of information yields a consistent and scaled model.

3.4 Application to the Pontonniers High School project

The modeling is complex due to multiplicity and diversity of the site buildings.

3.4.1 Project description

The set of buildings is divided in 7 different buildings (fig. 1), constructed between the 15th century and 1980. This division relies on the building's function. The periods of construction as well as the relations between the buildings and their different size are elements of complexity. The level of detail is defined by the final use of the model. Each object must be acknowledged to be true and show the formal features of the façades. Clicking on each architectural entity must be possible, in relation with the corresponding internal floor and other external variation of façade orientation. That means that those entities are limited to one floor of the building and horizontally by the orientation of the different faces.

3.4.2 Use of existing orthophotos

Before the modelling, orthophotos have been produced during the documentation stage. Content of the orthophotos is full of interest when characteristics of façades are required. Orthophotos will be used as textures in the final model. The geometric level of detail is not a priority in the model, but addition of textures allows identification of details of the object. Two types of information are given in the orthophotos: composition of the façade and dimension of elements (at least for those parallel to the orthophoto reference plan). In our approach where definition of relations between geometrical entities precedes dimensioning, the modelling from this type of image makes things easier.

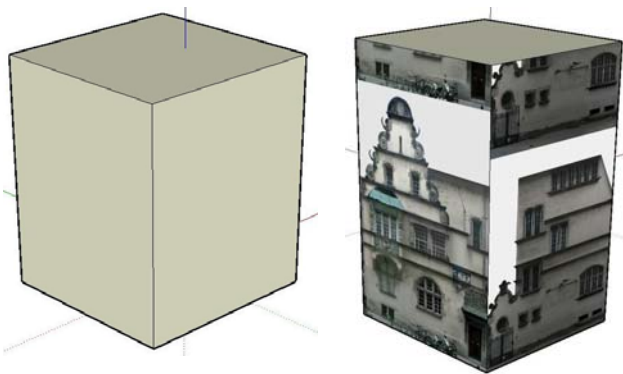


Fig. 5. Building B: global volume and importation of textures

3.4.3 Modeling

This step of geometric modeling yields to the creation of textured models in VRML format. Orthophotos have been imported in the model in an early stage of the modelling, and Sketchup software package has been used. This software intended for conceptual stages of design yields creation of 3D

sketches quite easily. We produced VRML formats for our models from the export option of this software.

The global shape is defined by importing orthophotos in the model. Orthophotos are used to scale simple shapes of the model. Faces of the model correspond to faces available in the orthophotos.

For the definition of the geometric relations, images are used to make divisions in the model and to define its final shape. Cut-out lines are drawn on the faces and positioned in front of or behind the corresponding plane. The set up of the faces is implicit due to the use of orthophotos in the modeling process: as an example, the roof is on the top of the façade. In the same time the façades are divided into faces corresponding to architectural meaning (fig. 6). Each face will be clickable in the Web interface.

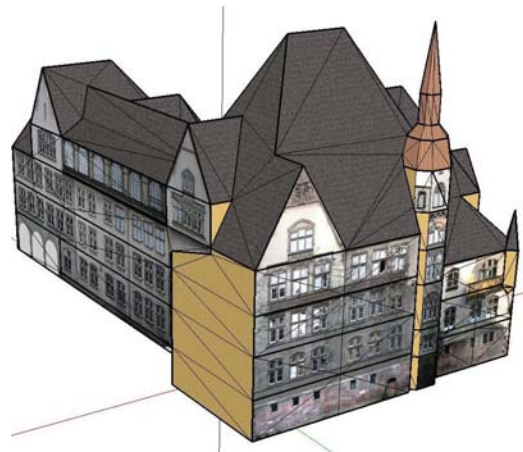


Fig 6. Building C: horizontal and vertical divisions and definition of clickable faces

Export to VRML format follows the definition of the geometric model. The interesting point concerning the VRML format is that the textures are recorded for each face. To scale the model with dimensions, we import and reconstruct the geometry in AutoCAD© from 3D points of the photogrammetric project. Two different ways are considered for the integration of dimensions. As the model has been created from orthophotos, all corresponding geometric faces have accurate dimension ratios. For the dimensioning, just the scale factor of the façade and the absolute orientation is required. The final 3D coordinates are finally merged with the VRML file which includes the textures. Links to informative content are added afterwards.

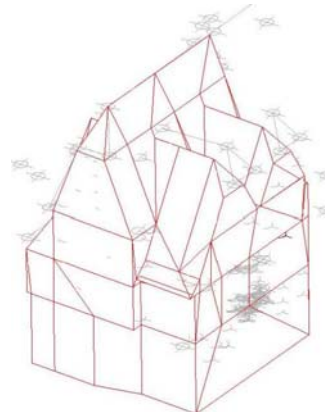


Fig.7. Building A: 3D points imported into AutoCAD© for the scaling of the model

4. IMPLEMENTATION OF THE WEB INFORMATION SYSTEM

The technical computer platform carried out is based on free software. Clients use traditional browsers like Internet Explorer, Mozilla Firefox or Netscape. The main interface is accessible through a PHP web server like EasyPHP. Web pages of the site are coded in PHP and JavaScript, with the use of CSS style sheets. Connection to the database is done thanks to a PHP script language. Queries on the database are written in SQL language. The database system is MySQL. 3D models are described in VRML, widespread language currently for the visualisation of 3D scenes on the Web. The following schema (Fig. 8) illustrates the computer behaviour of the developed platform.

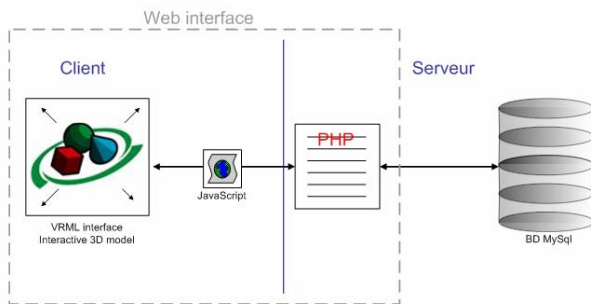


Fig. 8. Schema of the computer behaviour of our web Information System.

The creation of the 3D model of the high school is a preliminary of any other operation. Each face of the model is identified and made interactive thanks to an "anchor system" in the VRML file. At this stage, it is possible to click on each face of the model, both to fill the fields of the table of the face (in MySQL database) and to consult or modify the information about the face if they have already been recorded. The user interface of the information system has the following form:

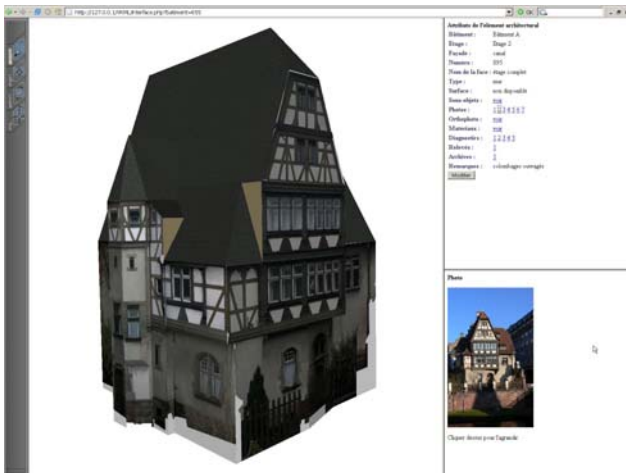


Fig. 9. Interface allowing access to the documents (building A)

The main window contains the textured 3D model. This model is described in VRML and is displayed in the Internet browser thanks to the Cortona (ParallelGraphics) plug-in. This model is interactive: when the mouse goes over the model, the name of the faces appears as a label and the mouse takes the form of an anchor. The user is thus informed if the face is (or can be)

recorded in the database. Then, when we click on the face, the descriptive form containing its attributes opens in the right up window. These attributes can have very different types: wording, level, surface, materials, photos, etc. The HTML pages showing these attributes in the interface are created on the fly by the PHP interpreter, which searches (SQL query) the information about the clicked face in the database and displays it according to a chosen form, notably through a CSS stylesheet. Among the displayed attributes, some like the photos are not directly visible, but will open in another window (right down). It must be clicked on the number of the photo in the attributes window and a miniature of it opens in the lower window (see Fig. 9). Then, when we click on the miniature, the photo opens with its original size. Other linked files as for example topographical maps can be open directly in the AutoCAD® software. The materials of the clicked architectural element themselves will be displayed in the lower window, under the form of a table containing the material type and its surface.

This description is only a small overview of the possibilities of the system carried out. All the architectural data quoted before has been integrated in the general database (regarding the management of the high schools) of the Alsace area. It is then possible to reach through the 3D interface all kinds of data linked to the working and to the management of the high schools, like for instance information about the state of the buildings, accommodations, parcels, safety devices, etc. Only the PHP programs used to form this data in HTML pages created on the fly when clicking on the 3D models have to be written. Thus, each actor working on the high schools can have access to the information concerning his scope, and if he modifies something, he can directly update the changes done in the database. The web information system developed is then accessible and simple to use, like wished in the specifications. The updating of the database is easy and original, since it is made from the 3D representations of the built heritage to manage.

5. CONCLUSION

The models and tools developed will be tested in the coming months. All data of the diagnosis and other documentation prepared by the different companies involved in the project are available through the web interface.

3D models of the site buildings seem essential for further analysis and studies, providing geo-referenced data for the user and visualisation in order to know the state of the buildings and manage future works.

Architectural data described in the paper will be integrated in the overall database of the Region Alsace Institution. The update of the database is therefore possible directly by browsing in the 3D building models.

After a testing period, the system will be adapted and a tender document will be prepared in order to extend the creation of information systems for all the 77 high schools managed by the Alsace Region Institution.

Further investigations for the update of 3D model and its adaptability in case of building modifications as well as integration of data from laser scanning will be considered in the future.

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<http://www.map.archi.fr/theme1/axe/axe3/SourcePdf/MULTIR EPINTERNET.pdf>

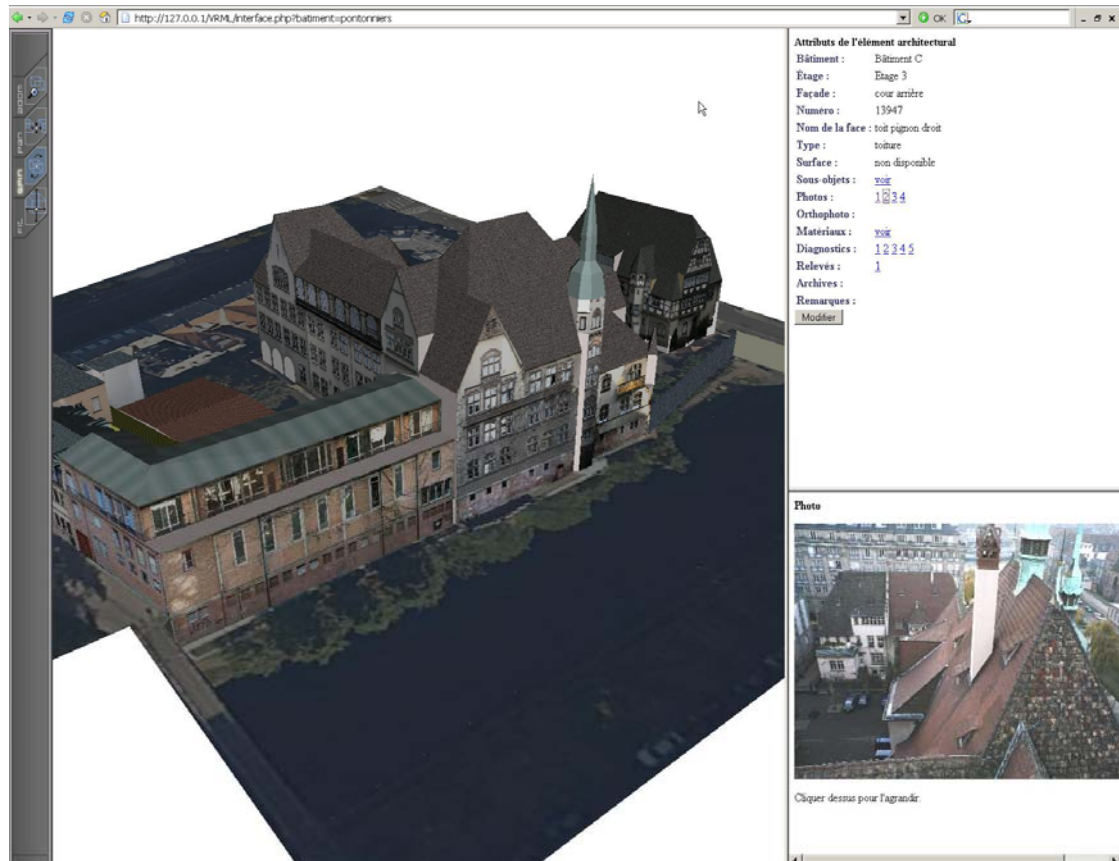


Fig. 10. View of the global 3D model showing the whole site in the web interface. Access to the information of each building is possible like in fig. 9