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► To cite this version:

Elise Meyer, Pierre Grussenmeyer, Jean-Pierre Perrin. First proposals for a web-based information system in archaeology: storage and interactivity for the preservation and the handling of Cultural Heritage data. the Third Taiwanese-French Conference on Information Technology (TFIT), 2006, Nancy, France. pp.195-211. halshs-00264547

HAL Id: halshs-00264547

<https://shs.hal.science/halshs-00264547v1>

Submitted on 27 May 2008

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First proposals for a web-based information system in archaeology: storage and interactivity for the preservation and the handling of Cultural Heritage data.

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Key Words: data management, database, information system, Internet, archaeology.

Abstract:

In the context of archaeology, information technologies begin to have an important role. This is particularly true for the management of the numerous data gathered about an archaeological site, and for information exchanges. The purpose of this paper is to present the first implementation of a web-based information system for the conservation, handling, and use of archaeological site data. The case study is the castle of Vianden in Luxembourg, on which considerable archaeological data have accumulated over the last several years. There is a recognized need in archaeology for a tool that will allow for fast, effective, and flexible exploratory analysis of the data, especially at spatial and temporal levels. We have developed such an information system on the web, with maximal portability by using Extensible Markup Language (XML). Taking into account the complexity and heterogeneity of archaeological data, our system consists of several interfaces permitting different types of access to the varied information. We propose a description of the data in textual interfaces along with images, and dynamic links to these data through interactive 2D and 3D representations. The 2D images, photos, or vectors are generated in Scalable Vector Graphics (SVG), while 3D models are generated in Extensible 3D (X3D).

1. Introduction

This paper is devoted to the presentation of the first implementation of a web-based information system applied to the medieval archaeology case study of the Vianden castle, Luxembourg. This work comes within the context of research conducted as part of a Ph.D. thesis entitled "3D acquisition, restitution and imagery in archaeology: towards a platform linking computer graphics and cultural heritage data". This project is managed in the Photogrammetry and Geomatics Group MAP-PAGE, INSA Strasbourg, in collaboration with two other laboratories of the group MAP, UMR CNRS 694, the MAP-CRAI of Nancy and the MAP-GAMSAU of Marseille.

The article is broken down into two parts: the potential of computerization for the management of cultural heritage data and the first proposals for a web-based information system on the Vianden Castle, Luxembourg.

The first part gives some explanations on the increasing role of information technologies in the context of archaeology. It describes the reasons for computerizing archaeology, explains the construction of databases and information systems in the archaeological problematic, and finally shows the benefits of data computerization for the archaeologists.

The second part presents the first implementation of the system that we develop. It explains the different data types that are at stake in the system, the creation of the XML database, the generation of SVG and X3D interfaces, and the way to update and revise the data.

2. Potential of computerization for the management of cultural heritage data

Archaeological processes give out a large quantity of cultural heritage resources that must be managed in order to profit from them. The fields of application for computer science in archaeology are thus numerous and diverse: field recording, archiving, predictive modelling, combinative studies, analyses of watched facts, data combination and cohesion, etc. To make the most of the computer tools potentialities proves to be necessary, taking into account the quantity of data that are released (difficult to handle efficiently with usual means). Moreover, the treatment of the various data as a whole is required to be able to carry out syntheses, e.g. for the publication. We must then make easier the consulting of excavations archives and the crossing of information, what can be translated in data processing terms by the development of Databases and of Information Systems to handle them.

2.1 The reasons for computerizing archaeology

An archaeological excavation is destructive by definition, and it is required to memorise what the archaeologist ruins during it. Hence, the excavation's quality depends essentially on the accuracy of the surveys carried out on the field (the recording system must ensure the documents reliability), and on their presentation in the results' publication. From a practical point of view, every person in charge of an archaeological site is faced with some problems explained in Table 1.

speeding up of the recording process of excavated data	because the vestiges have been deteriorating at great speed for years or to avoid to reside in the field more than necessary, e.g. if found relics blockade the site of a new construction
treatment and management of excavation's archives	to preserve it and to organize it at best: for the different analyses to be carried out in an optimal way
insertion in the same medium and comparison of data	data which source, type, format can be very various (objects and reasoning, images and texts, etc.), and that must be confronted for classification, dating, comprehension, etc.

Table 1. Problems of archaeologists on a site.

The computerization of processes and data allows for instance:

- to facilitate the access, the control and the handling of the information;
- to constitute a digital documentary base and a technical normalized reminder;
- to convey the data (the computer is an essential auxiliary for the achievement of publications and for exchanges with other institutions);
- to avoid that the studies lead to work where the data of each expert, because they are isolated, keeps devoid of a part of their sense.

The possibility to use and revise data synthetically "in deferred time" is an undeniable advantage permitting best results in the source's treatment (more objectivity and more investigation time). Furthermore, an important aim for the computerization in archaeology is the publication of the findings and of the analyses' outcomes. In fact, the lack of reports slows the progression of research and data acquisition processes, whereas it would be encouraged by the integration of perfectly documented materials.

2.2 The construction of databases

The computerization of data in archaeology requires the construction of databases that consists of the digitalisation of the available resources. The databases systems include the numerous benefits of the computerization, since they contribute to keep the consistency and the reliability of data in time. Accurate and dependable databases of archaeological sites could be valuable for the prospective labours to be carried out on these fields: reconstitution, maintenance, publication, exhibition in museums, etc. They are the "virtual memory" of the site. The most prevalent today in archaeology are for the majority established for the management of sites or monuments' groups at regional or national levels. There are few cases where the database technology is used for the management of documents at a site level.

To construct usable databases, it must be seen notably:

- to supply a database enough objective to set up a reconstruction of the past, which will not be purely speculative (no personal interpretations adding directly to the data);
- to create a database under the condition to be rigorous and to check that it contains as much information as possible (under different forms according to the later use of the data).

This last point is very significant because the more relevant information is contained in the database, the more it is interesting for the utilization by the future information system that will be based on this database. The value of the acquired data depends on the ability to extract information from these resources (an information being the addition of data and semantic elements). Extracting information is necessary to reach decisions and to understand the source or the object. Afterwards, it is required to take out the essence of information, that is to say to do a reading of them according to the end towards we work (modelling, interpreting, dating, etc.). To use at best the data and the sources that we have, we will then try to reduce the documentary base to a set of synthetic information or of significant indicators.

To end with, the database will contain an object (or a layer) to which we attribute a number, coordinates, the source (identified and documented), qualitative descriptors, relevant documentation (especially the bibliography of the source), comments, etc. From this point, it must be thinking about some other problems: indexation, establishment of thesaurus, categorization, management of the redundancies, knowledge organization (detection of incoherencies), etc. The aim is to carry out a database as clear and full as possible, and exportable to a management system.

2.3 The Information Systems: generalities in the archaeological problematic

Once one or several entire and reliable Databases have been generated, they have to be correlated with an Information System. Most of the time we speak about Geographic Information Systems (GIS), but the principle of the "Information System" can be applied to all kinds of information. The management of the database by an information system provides an enrichment of information, in permitting the immediate confrontation of all sorts of data at disposal: archaeological (and archaeometrical), historical, architectural, geographical, topographical, geological, environmental, etc. Today, the most of these systems are developed for the management of geographical resources. It is probably the lack of a good theoretic environment in which to undertake analyses on the scale of an archaeological site that limits the use of information systems for the working on of excavated data. In fact, this affects directly the quality of the resources found in the site and the relevance of their archiving. Nevertheless, as said before, the quantity of the collected data prescribes to manage them by means of computer science, and information systems are the best way to succeed in doing this efficiently and to extract of them the maximum of edifying results. A need expressed currently by some archaeologists leads towards a tool that will allow an "exploratory analysis of the data", which have to be fast, effective and flexible, notably at spatial and temporal levels in case of large-scale information systems.

The quality of an information system is estimated by its capacity to present information in a useful way, as fast as possible. In fact, considering the project of a person at a given moment and in a given environment, what does matter to him is to obtain a clear depiction of the tools he have at disposal to visualize the documentary base in different ways. An information system is then constructed keeping in mind the need to acquire quickly the best information elements that will give answers to experts'

questions, and to make these elements available for interpreting studies. Such a tool must so permit to carry out a real multidisciplinary synthesis of all resources of the database.

To extract data from the database, they are put through various types of successive or simultaneous selections, and visualized in tabular form, exportable graphic, three-dimensional model, etc. In all cases, the corpus of the final interesting documents is constituted by gradual refinements of queries (search by key-words, Boolean operators, proximity operators, etc.).

For archaeological data especially, the creation of an information system can lead to achieve:

- to treat graphically several information derived from very different kinds of surveys, because a selective superposition could be a precious help for the interpretation;
- to combine elements selected in diverse graphs for the carrying out of visualizations in a synthesis plan;
- to present images and their connexions with the concerned texts from the database, to lead to a complex system in which the examination of texts and images would be possible simultaneously.

Data should be reachable through graphical interfaces proposing arrangements that reflect the organization of the documents, and "surfing" in the information could be possible through a succession of various representations (cf. part 3.).

2.4 The benefits of data computerization for the archaeologists

The computerization potentialities explained before involve the idea to perform projects to manage and make use of archaeological data, on a site scale. Some advantages of such projects are mentioned in Table 2.

More durable memorizing of acquisitions, what is interesting above all if the site disappear because of new constructions.
Help for analysing and understanding the excavated data of the site, through synthesizing (overview of all available data) and quick confrontations of different types of documents.
Digital restitution of the successive states of the site and modelling of historical evolutions.
Proposal of tools for the working out of reconstitution hypotheses or for the validation of already made reconstructions.
Aid for the dating of elements, thanks to the simplicity of comparison between various data.
Identification of data sources or of objects origins by confrontation of similar documents coming from different archaeological fields.
Conveying the knowledge: the virtual imagery is eloquent and the interactivity with the model is attractive and instructive.
Emphasizing of the site and improvement of the museums exhibitions.

Table 2. Benefits of management projects for archaeological work.

This small listing is only an outline of the numerous new developments, to which an entire integration of computer science in archaeology could lead, and other advances would appear with the fast evolutions of the data processing.

The next chapter presents the first implementation of the web-based information system that we begin to develop to allow the archaeologists to take advantage of these evolutions.

3. First proposals for a web-based information system on the Vianden Castle, Luxembourg

The system attends in a web site form to allow a maximal accessibility for everyone. The Vianden castle has a very rich history and a lot of documents have been created and hold during it. Taking into account the complexity and heterogeneity of these documents, our system consists of several interfaces permitting different types of access to the varied information.

We propose a description of the data in textual interfaces along with images, and dynamic links to these data through interactive 2D and 3D representations. All the data are described in Extensible Markup Language (XML), standard language of the W3C (World Wide Web Consortium), for the portability of the system and to facilitate information exchanges. The 2D images, photos, or vectors are generated in Scalable Vector Graphics (SVG), while 3D models are generated in Extensible 3D (X3D).

Aim of this web site, including the information system, is to assist the digital archiving of the documents, their inquiry and their processing by everyone, both the professionals (archaeologists, surveyor, architects, etc.) and the general public. These documents are paper plans and drawings that have been digitized, digital photographs, scanned texts from ancient or recent books, digital drawings in SVG format and 3D models in X3D format. The two main form of queries available are queries on the different building periods of the castle and queries on the geographical places distinguished in and around the castle.

3.1 The different data types in the system

The Vianden castle is a medieval castle located in Luxembourg. It has been built during a long time, from the 4e s. to around 1820, and reconstructed. So, ten building periods have been derived from the history of the castle and therefore, the first object type in the database is "period". Each period has also a descriptive form and a lot of related objects that refer to it. It is the first "query unit" that can be drawn, in the system, from the study of the castle. The browsing interface corresponding to a period looks like Figure 1.

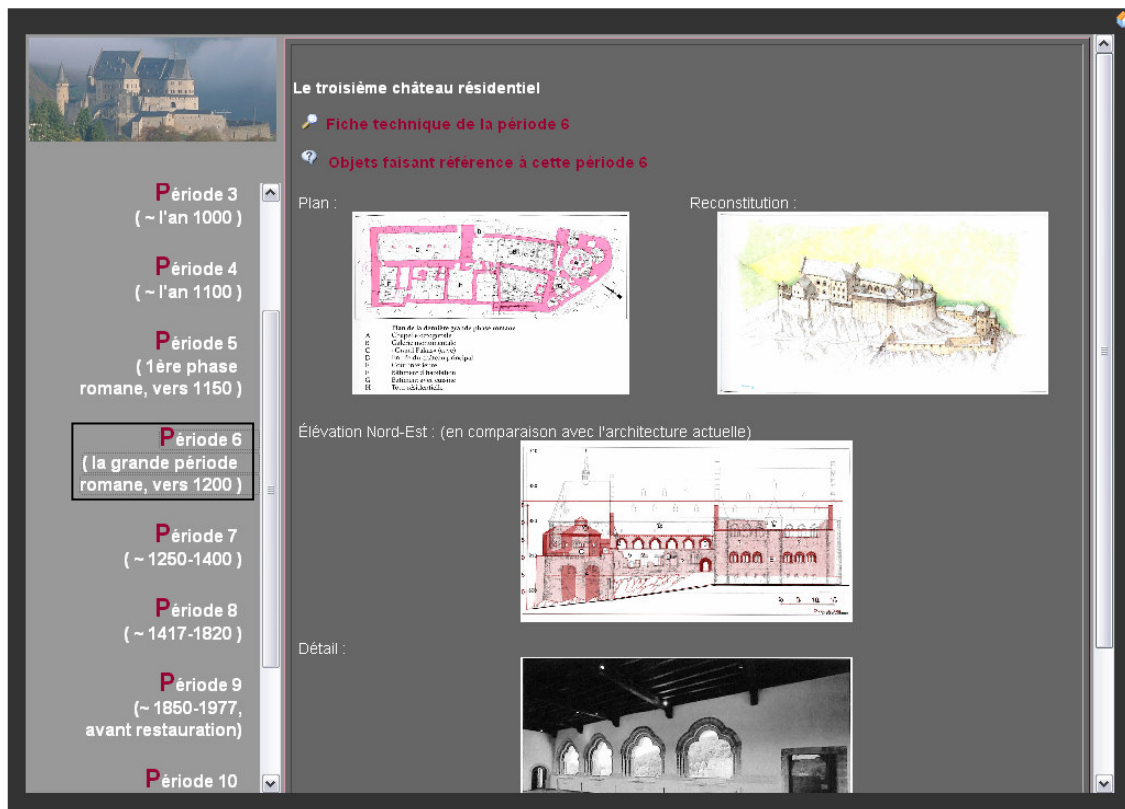


Figure 1. Browsing interface corresponding to the 6th building period of the castle.

The second main "query unit" is the object type that we have called "place". In fact, many different and remarkable places are distinguishable in the castle. They correspond to the existing rooms of the castle, but also to the important places that are partially destroyed or that have disappeared, and to the exterior elements. The menu for the "virtual visit" of the castle is presented in Figure 2.

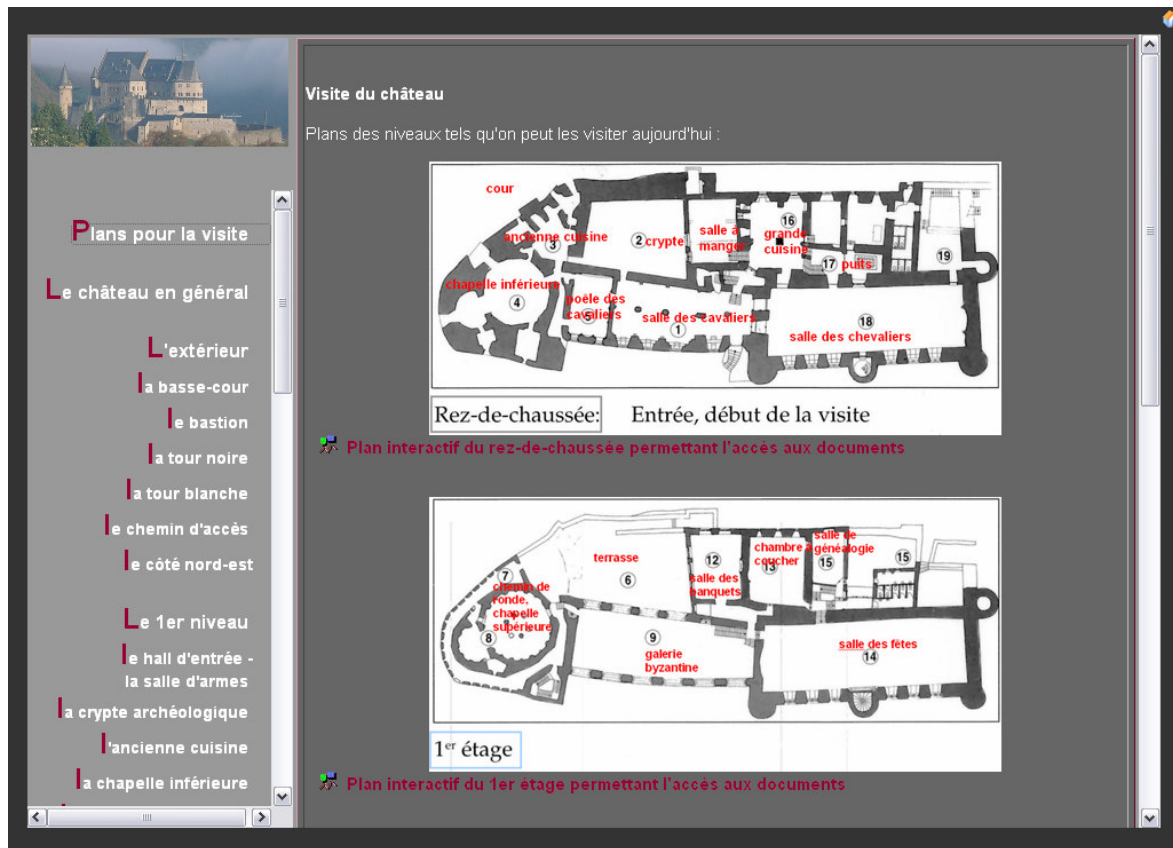


Figure 2. Menu for the "virtual visit" of the castle's places.

The other data types that have been integrated in our system, and that the system allows to manage, are:

- different sorts of plans that have been digitised (axonometries, maps, sections, plans, elevations, excavation profiles and plans) ;
- digital photographs or ancient photos digitized ;
- scanned drawings ;
- scanned texts (of all epochs) ;
- vectorial plans (generated in SVG) ;
- and 3D models (generated in X3D).

These types of documents are considered as "object types" in the system, because they constitute the main source of documentation about the castle. They are accessible by queries through the web site and through the interactive 2D and 3D representations that have been generated (thanks to surveys notably). To be able to formulate queries on the periods and on the places, each of these object types has for attribute a list of period and a list of places that it refers to.

All these data types have to be recorded and classified in a database, so that they can be managed by the information system.

3.2 The XML database

XML Extensible Markup Language is a meta language to structure information. XML uses tags, keywords in angle brackets with additional attributes, to enclose content. Compared with HTML, the denotation of the tags is not defined and will be interpreted afterwards by the application. XML files are plain text files. Rendering XML files requires other technologies (parsing). XML documents are starting

with a prologue, followed by the root element. For example, for an object type "place", the prologue is the following:

```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<?xml-stylesheet type="text/xsl" href="/ISA-PX/arbre/arbreForm.xsl"?>
<place>

<!-- content of the document -->

</place>
```

An element and its sub-elements will be represented in the tree structure by nodes. The element itself consists of a start-tag, the content and an end-tag. Attributes will be added into the start-tag. A Web browser displays the tree structure of the document. By simply clicking the symbols (+, -), the nodes can be closed or opened, as shown in Figure 3.

The style (on the web page) of the root element `place` is defined in an external XSL Extensible Stylesheet Language document (in the example `arbreForm.xsl`). The XSL provides transformation from XML into another better readable format. A XSL processor can be applied by the Web browser or, as an alternative, server sided by the application. An off-line transformation results in a HTML document to be stored on the server. An external XSL file must be referenced in the prologue using the statement quoted above. HTML tags must be combined with XSL statements to obtain the final form of the object, as shown in Figure 4.

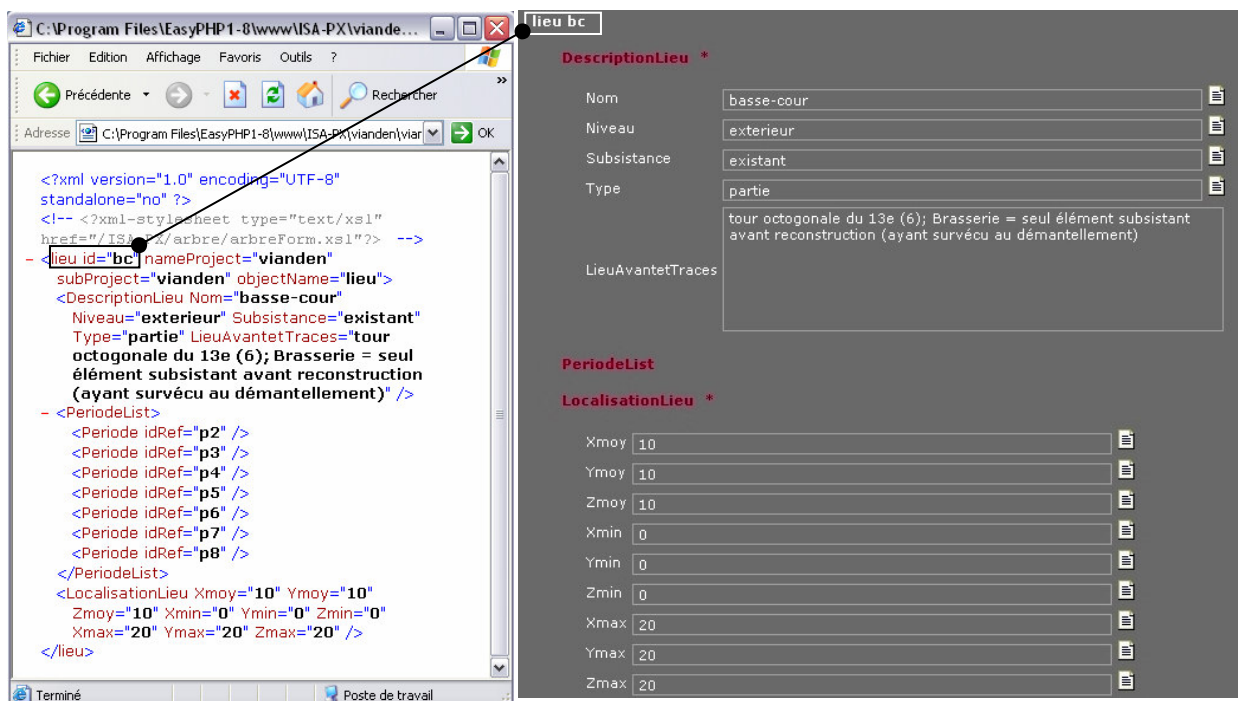


Figure 3. Tree structure of a XML document.

Figure 4. Final form of a XML document thanks to an external XSL document.

At the beginning, an example of each data type has been entered in the database under the form of a simple XML document generated in a XML designer. After that, the type of each object identified (plan, text, drawing, 3D model, ...) is memorized in the system and the documents can be recorded in fulfilling a data entry form created thanks to a PHP program. The recognizing of the document type and the using of the XML data is possible thanks to a parser. The parser analyses and validates the file structure. Events are the occurrences of tags and content.

Then, when we enter the description of a new document in the data entry form, after the parsing of this file, the system produces, for each object, an XML file with the relevant data. A corpus with all the values of all the attributes is also available without any action of the user. At the same time, a MySQL database is populated.

Below, the Figure 5 gives an example of data access through the information system integrated in the web site and directly through the MySQL database.

The top screenshot shows a web interface with a sidebar on the left containing links like 'Évolutions historiques', 'Visite des lieux', 'Bibliographie', and 'Base de données'. The main area displays a 'Set (Page 1)' view with a grid of icons representing different periods. A callout window for 'periode p3' shows the following details:

- Nom: periode3
- Description: moyen-âge
- Dates: vers an 1000

The bottom screenshot shows the phpMyAdmin interface for the 'vianden_periode' table. The SQL query is:

```
SELECT * FROM 'vianden_periode' LIMIT 0, 30
```

The table view shows the following data:

	id	col1	col2	col3	col4	col5	col6
<input type="checkbox"/>	p2	vianden	vianden	periode	periode2	haut moyen-Âge	6e-10e s.
<input type="checkbox"/>	p3	vianden	vianden	periode	periode3	moyen-Âge	vers an 1000
<input type="checkbox"/>	p1	vianden	vianden	periode	periode1	bas-empire, fortin	4e-5e s.
<input type="checkbox"/>	p4	vianden	vianden	periode	periode4	1er chateau residential	vers an 1100
<input type="checkbox"/>	p5	vianden	vianden	periode	periode5	1ere phase romane, 2e chateau residential	vers 1150
<input type="checkbox"/>	p6	vianden	vianden	periode	periode6	grande phase romane, 3e chateau residential	vers 1200
<input type="checkbox"/>	p7	vianden	vianden	periode	periode7	phase gothique	env. 1250-1400
<input type="checkbox"/>	p8	vianden	vianden	periode	periode8	declin	env. 1417-1820
<input type="checkbox"/>	p9	vianden	vianden	periode	periode9	1ers travaux, restauration, ruines	1850-1977
<input type="checkbox"/>	p10	vianden	vianden	periode	periode10	restauration par le gouvernement luxembourgeois	1977-...

Figure 5. Different types of access to the data: interpreted XML (up) and MySQL database (down).

Moreover, the same data (for example the descriptive form of the 3rd period, like in Figure 5) can be accessed through the period menu (Figure 1): if we choose the item "Période 3", we have an access to some images of the castle in this period and also to the direct link with the descriptive form of the period and with the form that presents all the documents that have a relation with this period.

As we can see, the system allows to access the data in very different ways what gives the users a large navigation flexibility. Additionally, these are not all the access possibilities: some 2D and 3D interactive plans and models have been generated to permit another access type (more spatial) to the data. The following chapters explains how these interactive representations have been carried out.

3.3 The SVG interface

Scalable Vector Graphics SVG is the XML formulation of 2D vector graphics. It was therefore chosen because of its multi-platform and full compliance with XML specifications. It includes drawing of vector data, displaying of image data, interaction and animation. Structure and appearance of graphic elements is separated by using style sheets. Applying a SVG viewer as a plug-in for the Web browser enables zooming and panning in the graphic area. Furthermore sophisticated design possibilities like pattern filling, shading, insertion of symbols and others are provided by SVG.

The above potentialities of SVG were used by building a representation which gives quick access to the dataset by means of templates defined by the user: archaeological templates, photographic templates, typological templates, etc. The PHP interpreter allows access to the file system of the server and a JavaScript program permit the interactivity between the SVG graphic and the information system. By clicking on different zones defined in the SVG drawing, we access the corresponding form showing the elements that refers to the clicked zone. The Figure 6 illustrates an interactive interface in SVG, which corresponds to the first floor of the existing castle.

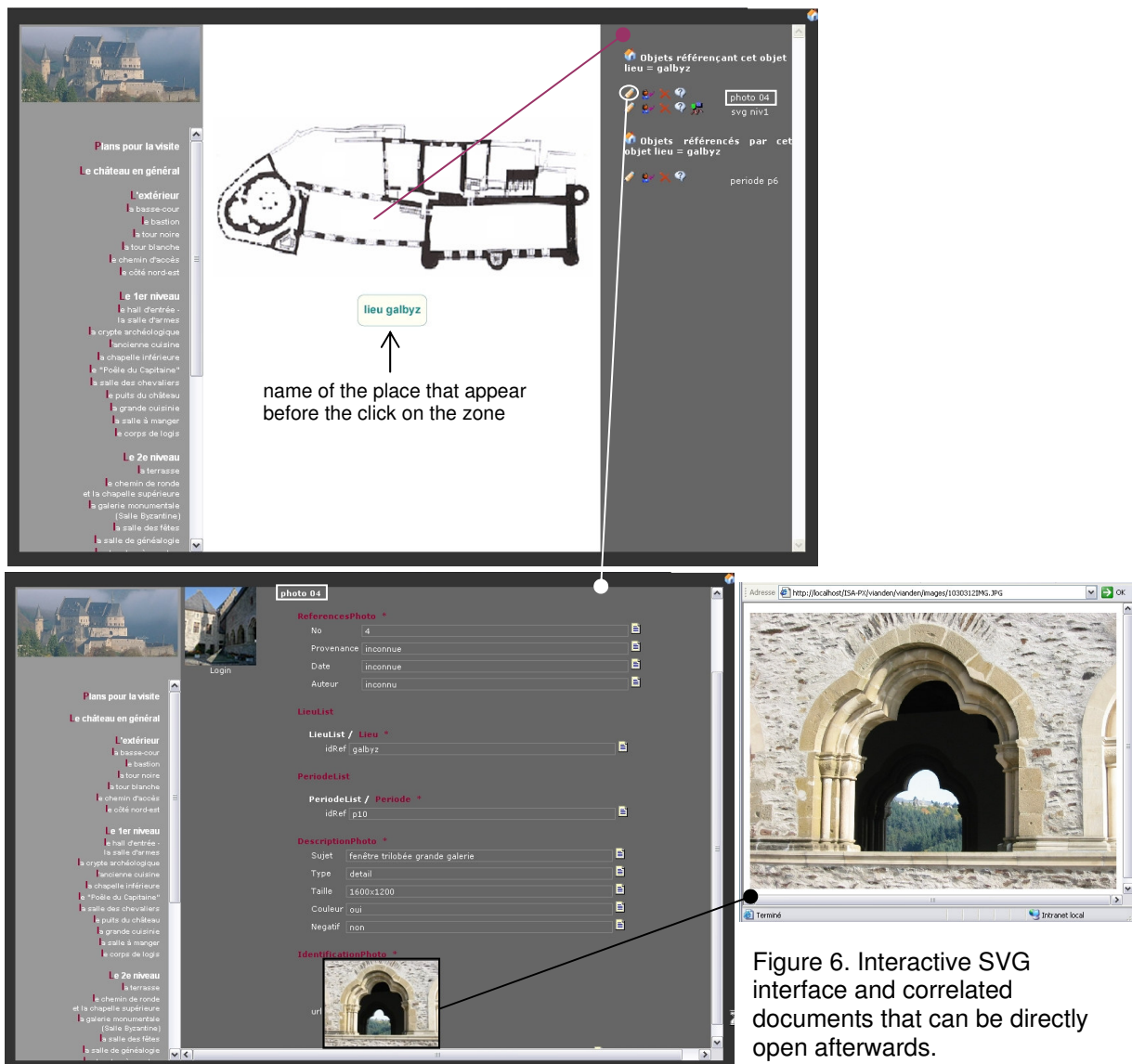


Figure 6. Interactive SVG interface and correlated documents that can be directly open afterwards.

This interface in 2D can be useful to complete the 3D interface that we will be explained below, because the archaeologists (notably) are more used to work on 2D representations than on 3D models. So, we have created some 2D interactive graphics to allow moreover an other type of navigation in the data. As shown in the Figure 6, one click on a zone of the graphic permit to see for example the descriptive form of a photo that refers to the chosen place, and afterwards it is possible to click on the miniature of the photo to access to the original.

The same principle has been carried out for the search of information through 3D models.

3.4 The X3D interface

3D graphics data for the Web is known as VRML Virtual Reality Modelling Language description. That format convention is updated to the XML version, predicted as Extensible 3D X3D. The VRML code has just to be rewrite with XML conventions and descriptive elements to convert it to X3D format. A lot of viewer can be applied for VRML and X3D in stand-alone mode or as a plug-in for Web browsers.

The navigation through the 3D model is the same that in the 2D SVG interface, with all the additional possibilities offered by the 3D. The PHP interpreter and JavaScript are also used to access to the data that refers to the clicked element.

These 3D description languages are not powerful enough to build a bidirectional link between our system and the 3D representations. Currently these 3D representations are used as simplified interfaces between the 3D representations and the textual and iconographic data. A more generic description to enable a real interaction between these two aspects of the objects will be required shortly. Java3D seems to be the most powerful system for the task but is unfortunately too slow.

The Figure 7 gives an example of a 3D model generated for an external part of the castle, which allow to see the textual and iconographic information referencing this place and being referenced by this place.

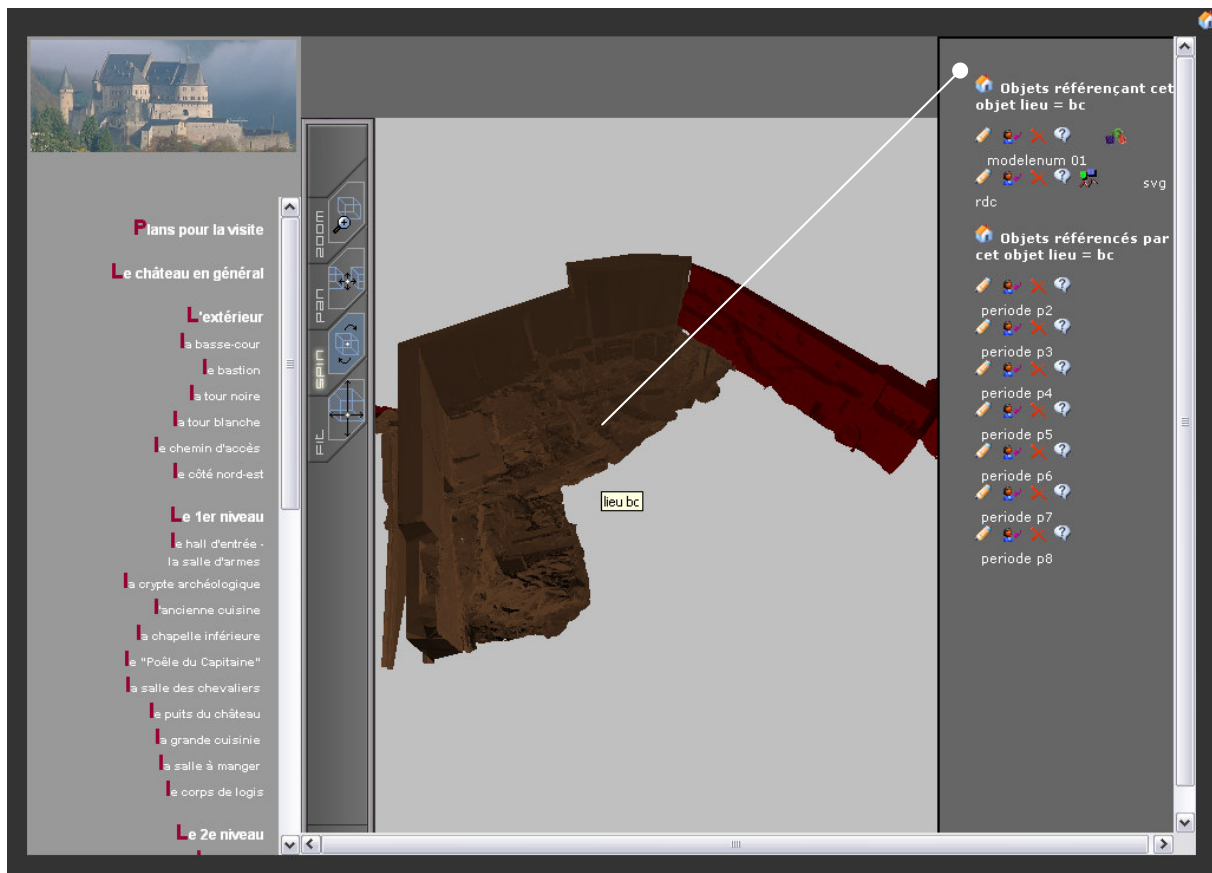


Figure 7. Interactive X3D interface allowing access to data referencing and being referenced by the place clicked.

3.5 Updating and revising the data

To look at the data is the first step in the analysis of a dataset. To go further on, the archaeologist (or any expert that is logged on) needs to entry/edit them.

To update the textual data:

- the corpus can be used to correct some basic errors (misspelling, simple inconsistencies, etc.) ;
- through the graphic interfaces in SVG or VRML, the user can directly modify the selected object ;
- through different types of research modes (by object type, by localisation, by epoch, ...), the user can straight access to the data and can edit it for modifications.

For the revising, the conceptual model used to describe the objects can change during the time of the study, according for example to new archaeological knowledge. The user can modify accordingly the tree structure of the dataset describing the object model.

4. Conclusion

The work presented here highlight in a first part, the increasing role of information technologies, particularly of databases and information systems, in the scope of archaeology. Notably on the scale of an archaeological site, there are for the moment few completed work on this subject, and there is a recognized need in archaeology for such tools.

Then a proposal of web-based archaeological information system has been made, to search solutions to help archaeologists in their tasks. The feature allows combining a representation of the architecture itself to a database serving as a tool for the analysis of its units. A full XML choice for textual and graphical representation permits a relevant interaction. The use of 2D vectorial graphics and 3D models as user-interfaces to the data formalized in XML link the purely documentary data (references, plans made during the excavation, photographs, texts, elevations, etc.) to geometric representations of the object. We connect very different types of data to emphasize new research possibilities and new information exchanges between many sites of the same epoch for example, to be able to draw conclusions by crosschecking. Finally the data access through the Internet and the XML formalism allow us to work in the direction of updating and revising data from their 2D or 3D representation.

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