Online 2D/3D graphic interfaces using XML “repurposable” heritage contents

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ABSTRACT

In the field of the architectural heritage, documentation analysis and organisation are vital to the researcher when trying to understand the evolution of edifices and sites. Documentary sources provide partial evidences from which one will infer possible scenarios on how an edifice may have changed throughout the centuries. But the growing mass of documents researchers handle has underlined the necessity to find out solutions for enhanced interfacing and visualisation of this wide and heterogeneous documentation.

On the other hand, 2D or 3D representation has historically been at the heart of the way edifices or sites are described, visualised, documented and understood. Why shouldn’t it be so today? State of the art in our field shows this is far from being a reality. 2D graphics, with the development of SVG-based applications, have undoubtedly found a role in geo-visualisation, but not yet in architecture. Moreover, 3D models most often remain only in relation with communications goals. Virtual renderings, although presented as visualisations of an edifice, mask the semantics behind the scene. Such seducing results may be of a great use, seen as visualisation of geometrical shapes, but in no way can they be considered as visualisation of the deeply *uncertain* architectural heritage data. The paper proposes an approach of data visualisation in which graphic codes help in interpretation. Appearance of an object represented in a scene, shows the actual level of the knowledge about the object (included in the ensemble of analysed documentation). The documentation is provides links to architectural concepts with respect to the notion of scale. Dynamically generated 2D/3D graphics are used both as visualisations of the documentation’s analysis and as interfaces to the documentation’s database. Our experimental set is the historical centre of the city of Kraków (Poland).

The paper introduces the recent developments of our research: the handling of multiple scales and consequently of multiple interfaces (2D/3D), the use of each object’s “repurposable” XML data in the dynamic generation of graphics, the creation of “timeline” scenes that graphically simulate the city’s evolution.

Keywords

Applications, scientific visualisation, architectural heritage, SVG, VRML, spatial information.

1. INTRODUCTION

When analysing architectural evolutions, researchers base on the interpretation and comparison of a growing mass of heterogeneous documents, as stated in the [Cra00] charter. This analysis affirms:

- credibility of a piece of an information,
- relation between an architectural element (an edifice, a portal, etc.) and documentation,
- a historical period that is concerned.

In other words, documents related to edifices or sites, should be given a specified level of credibility, that shall not be mask at any stage of the research process, including inside graphics.

In parallel, as shown by [Cui91], the interdependence between documentation and visualisation has a history that goes back to the renaissance, and is today clearly acknowledged by authors as a key issue in graphics (see [Alk93] or [Nak99]):

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- Visual results can in no way be considered as elements of information in a research process if they are not put in relation with a documentation that authenticates, validates, explains each particular arrangement of architectural shapes the reconstruction proposes.
- Symmetrically, documentation about edifices can very hardly be given a synthetic visual interface when this interface does not refer to what the documentation is about, meaning architectural shapes. There is a need to use graphics both as interfaces and as filters on this documentation. Such graphics will help the researcher to evaluate visually how precisely objects are documented, and to retrieve thematically sorted information.

Finally, documentary sources relate to pieces of architecture at various scales (or levels of detail). Each scale calls for a representation that matches the morphological complexity of the objects concerned. In that sense, neither 2D nor 3D alone can fit the specific needs of architectural representation.

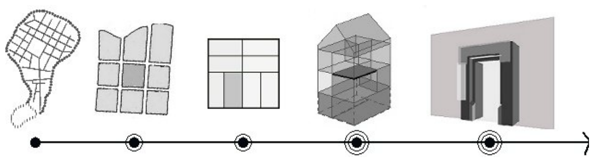

Figure 1. Scale, a necessity in order to match the architectural morphology's levels of detail as well as its documentation's variety.

The research presented in this paper address a *graphics readability* issue: how can one retrieve architectural documentation using the graphical signs available in the 2D/3D interfaces? How can one mark those graphical signs with indications about the content and analysis of the documentation, typically its uncertainty? These questions are important in our field, and remain widely unsolved.

1.1 Related works

2D graphics are particularly present in site management experiences using GIS (see [Seb03]). GIS enable a native connection of the graphical sign to the information it localises and signifies. But data to handle is connected to geographical concepts that are at best avatars for archaeological information (see for instance areas used for stone wall analysis in [Ioa99]). In parallel, a variety of researches on the exploitation of the SVG standard have been carried out in the recent years ([Fro02], [Jun03]). These researches have shown that the use of SVG in conjunction with other XML-related formalisms such as XSLT can be fruitful in exploiting spatial information (see [Mor02]). Why should architectural data, not benefit from these advances? [Gag03] does include spatial search with SVG inside heritage information but the visual sign on which the search is made remains purely geographical (a city location inside a region). [Kel02] underlines key points in spatial information services such as "on-the-fly" customised maps or "multi-channel output" that we believe can be of great benefit in our field of experimentation if and only if the visual sign delivered are in relation with the phenomenon observed, architecture.

In the field of geometry, and particularly in connection with support for surveying [Dek03], experiments have been carried out in order to attach information to the geometrical results of the survey, typically 3D points as experimented in [Whi97]. But in patrimonial architecture a 3D point or any other geometrical being is a totally irrelevant concept to attach information to. What historical reference mentions "*a 3D point*"?

Finally 3D graphics are also widely used in our field, notably in the virtual reconstruction of edifices targeted at a wide public. Such visualisations do seduce, but are nothing like a research or information tool, as discussed in [Kan00]. And although the research mainstream in 3D graphics for architecture still focuses on end-use issues such as real-time rendering, mobile technologies, etc. (see [Per03], [Vom03]), numerous authors have acknowledged the necessity to widen the scope of 3D models' usability.
When it comes to information visualisation, [Hei00] or [Lan98] have investigated the use of 3D models for information retrieval in the context of nowadays urban fabrics. In those two experiences the shapes stand for what they are: edifices, but their appearance has no link with the information behind the objects.

Alternatively, in the field of information visualisation, 3D graphics have been used to deliver "visual metaphors' that position the system's user inside search "spaces". Such metaphors may use virtual architectural spaces ([Gob03] [Rus01]) or may not ([Mul03] [And03]), but the graphical signs or beings in all cases have no direct relation with the information they represent: they are intermediates chosen for their readability. However they can be exploited like 2D graphics are in order to provide a semantic visualisation of information.
Experiences like [Hei00] or [Lan98] and experiences in "3D visual metaphors" all illustrate an ambition to demonstrate the central role of graphics in providing easier navigation tools inside information sets. They show a 3D model can be an interpretation, representing pieces of information, a conclusion we base on. Shortly said, although architectural documentation is naturally space-related since it documents edifice or sites (3D beings) located at a

given position in tile and space (2D being), it has not yet been given clear foundations for visual interfacing. Graphics used in architectural heritage are results, side effects of the documentary effort, but they are not part of a research process in which the graphics would represent our state of knowledge.

1.2 Methodology

In previous contributions, we have introduced our position on interpretative modelling in the field of the architectural heritage with regards to visualisation issues [Dud01] and on the use of 3D models as interfaces with regards to documentation issues [Dud02]. In the field of the architectural heritage, we believe that 3D models, showing various evolutions of the edifice, can act as an avatar for the edifice itself, and can thereby be the visual metaphor for architectural documentation. In our experience a 3D representation is metaphor, since plenty of edifices we deal with have been transformed and their previous shapes are unknown or uncertain. But our 3D representation provide readable avatars since they feature non-ambiguous elements of the architectural knowledge (“Arch”, “Gallery”, “courtyard”) to which documents can be attached.

We consider that the edifice’s shape can be used in order to interface documentary sources provided that the interface features the concepts people who document buildings deal with.

One can observe that although the edifice is not the information, the information is relative to the edifice. Our contribution investigates use of the physical elements of architecture as filters on the set of data architects, conservators or archaeologists handle.

In our previous contribution to WSCG [Dud03], we introduced this idea but also stressed the necessity to further investigate the question of scales. What we meant by that is the idea defended by [Alk93] and [Bou71] that the information that can be attached to architectural elements is related to the way we observe them. Let us take an example: Considering an edifice as a whole, one may describe its orientation, its composition, etc., but if one considers its portal alone, one may describe the stonework, or even indicate that it used to be part of another edifice. In other words, representing the edifice as a whole is NOT equivalent to representing the addition of its sub-parts. Although the geometrical features could in theory be the same, they anyway relate to different “information spaces”. This idea of scale, very present in architecture, seems absurdly absent from 3D graphics. As an answer, we have determined a methodological framework for supporting scale in which the theoretical architectural concepts that are identified and structured can be given alternative representation modes depending on the scale observed. Each such concept can be documented and then represented inside 2D (SVG) or 3D (VRML) interfaces dynamically generated so as to reflect the ongoing research process. Such scenes act as graphical interfaces to the documentation but also act as a visual statement on the documentation’s content and analysis.

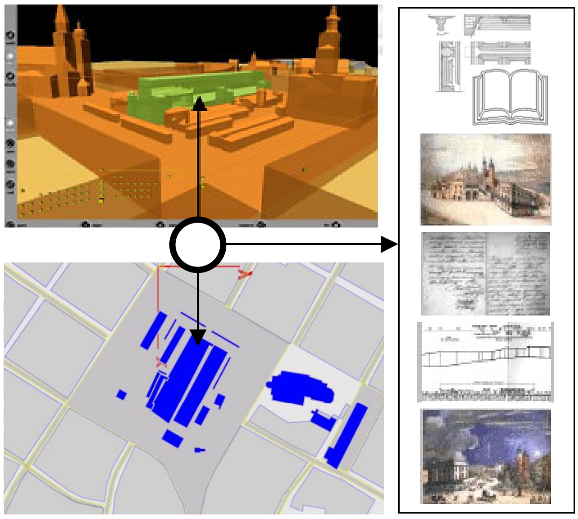

Figure 2. Localising, visualising and interfacing heterogeneous information by means of what it documents, (Sukiennice on Kraków’s Main Square)

2. ARCHITECTURAL REFERENCING

As mentioned above, we deal with architectural objects at various scales (edifices, urban blocks, individual arches, etc.) and with the relation to architectural documentation (multiple data sets). Investigating whether the former’s morphology can be used to interface the latter requires explication of the meaning we give to those two expressions.

I. In the context of our work, the architectural object is the realisation of a concept that describes a given element of architecture, identified by a given term in the architectural vocabulary (example: St Adalbert church - realisation of the concept of a church). An architectural object is defined by morphology suitable for the creation of graphics. Architectural objects that we study have been widely transformed throughout the centuries, their representation should be marked by a level of certainty (the object’s morphology may not be well known at early stages of its evolution). An architectural object corresponds to a given scale (comparable to a level of detail). Finally what we know about an architectural object is gathered in an architectural documentation every element of which is marked by its own level of certainty.

II. The architectural documentation contains elements that vary in type, precision and relevance. We may face partial evidence, contradictory evidence or lack of evidences. Architectural documentation contains raw material (historical data, surveys, etc.) or interpreted material, but also decontextualised fragments or remains. The major part of the documentation consists of bibliographic references. In all these cases the individual documents are traditionally described without a clear connection to architectural objects. There is therefore a need to carry out a phase of architectural referencing of the documentary sources. In that phase we define two parameters: what the document is about (which edifice, or part of edifice, etc.) and how credible it is. We can then propose visual markings of the objects represented in a 3D scene that correspond to the type and content of their documentation. Pieces of documentation we have provided solutions for today are on one hand a set of terms definitions/translations, visual material and fragments that are stored as XML files using relevant metadata frameworks, and on the other hand bibliographic references stored in RDBMS context.

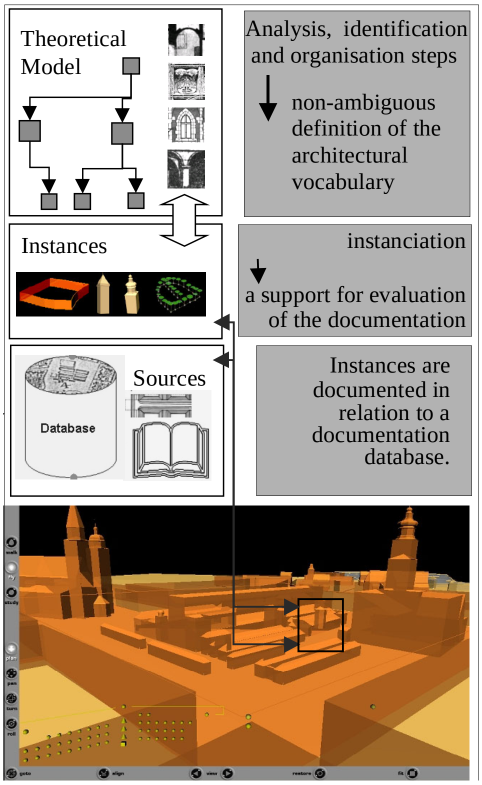

Figure 3. From the identification of concepts to the instances' visualisation .

Architectural objects are formalised by a hierarchy of classes with the root class factorising the attributes responsible for representing the documentation's analysis. This identification step is based on the analysis of respected scientific works (see [Per88], [Łuk98].) in which a careful attention to a non-ambiguous definition of the architectural vocabulary can be exploited for implementation in an object oriented programming language. Each concept isolated details several blocks of attributes, five mainly qualitative – and nested inside the root class – , one related to the class' morphology - class specific. Qualitative information blocks store the identification of the object and its localisation in the city, but also:

- A set of attributes called *Evolution block* fixing the dating of the object by an interval and a qualitative justification attached to the interval.
- A set of attributes called *Typology block* that provides a qualitative justification with regards to three themes (shape, structure and function).
- Finally, a set of attributes *called Documentation block* that states what are type of documents related to the object are.

Evolution and Typology information blocks detain **justification attributes**: they are used to represent objects with a graphical code that indicates how credible the information we detain is. Documentation information block detains **existence attributes**: they are used to represent objects with a graphical code that indicates whether or not we have documents on the object of this or that type.

3. ONE INPUT, SEVERAL OUTPUTS

Each architectural object detains methods relevant for persistence handling in XML files and RDBMS context. References on the documentation are stored in yet another database that describes what the data is (a book, a plan, etc.) and attaches this data to information on what it is about (an edifice, a part of an edifice, etc.). Each architectural object is identified by a unique Id, but its morphology may be described in several XML morphology files if the architectural object evolved through time (which of course is quite common). Morphological evolutions are stored in XML sheets, but their justification remains stored in the database.
We propose in line with [Wal02] a solution in which a unique input (the instance's XML sheet) has several outputs (i.e. VRML and SVG). The input detains morphological information about the object, as well as justification and existence attributes as defined above.

At this stage, the use of two different graphic outputs needs to be discussed. Some objects are naturally better represented in 3D - a complex vaulting for instance, for some 2D is more adequate - a grid of streets for instance. Finally, some convey different information when they are represented in 2D or in 3D: the layout of urban blocks is better read in 2D, but their proportion in relation to their environment can be more readable in 3D. In other words, one cannot do, what would seem most convenient: choose 2D for poorly detailed objects, choose 3D for rich-detailed ones. Architectural scale is not only about dimensions/quantity of details, it is about the information delivered. We in fact need to alternatively exploit the object's XML input in 2D or 3D depending on what the user wants to learn from it. Representation, in that sense, aims at providing avatars for querying and visualising data sets, not at cloning shapes and appearances of the real world. Scale acts as a filter commanding the type of representation of an object. Urban blocks for instance are represented at lower scale as 2D polylines and at higher scale as 3D indexed face sets. In this example, the same object is visualised across various scales. But of course no object encompasses all scales: one never "reads" the urban block when dealing with a ceiling inside one of the urban block's houses. Still the basic morphological information about the object, its XML input, needs to be exploited in producing either 2D or 3D outputs.

Besides, the evolution of our knowledge about morphologies should be reflected inside the interfaces. This means that we want 2D/3D interfaces not only to stem from the same input, but also to have this input evolving when needed. As a consequence, both 2D and 3D interfaces are dynamically generated at query time, thereby reflecting the current state of our knowledge. User queries are processed by the RDBMS, which sends a selection of matching architectural objects. Each of them is re-instanced by parsing their XML sheets. Each object then calls its representation method with as parameter the scale interrogated, and thereby whether to produce 2D or 3D output. The SVG or VRML files are appended. Both can be used recursively as query entries. Besides, commands nested inside either SVG or VRML interfaces allow inside filtering of the representation's content.

4. GRAPHIC INTERFACES

4.1 Appearance monitoring

Let us sum up what we use graphics for:

- They locate objects within the city/edifice/etc.
- They do not represent the exact morphology of objects (this we may ignore) but an interpretation of this morphology that lets the user to understand what kind of object it is.
- They provide, by an appropriate appearance, information on each object's documentation.

In order to achieve this third objective, the documentation is analysed in two main ways:

- Statement of its content (does the documentation for the object contain illustrations, inventories, etc.).
- Statement about its credibility.

These two families of indicators are in practical what we earlier called justifiers. They are stored inside the XML sheet, used at the time of dynamic generation of graphics. Graphics are created using the current value of these indicators. The appearance of objects is thereby natively a consequence of our analysis of the documentation.

Different indicators rule different graphical behaviours. Generally speaking, indicators about the documentation's content are used in highlighting modes, where the user checks interactively whether this or that type of document is available for an object. Indicators about the documentation's credibility are used in the control of the colouring or translucency of objects, etc. The way the information "semantically defined" in the XML file is exploited graphically depends on whether we are creating 2D or 3D graphics.

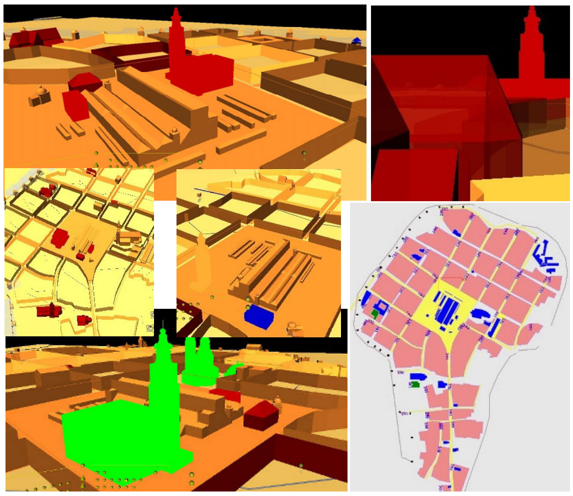

Figure 4. Appearances: a way to show our understanding of the architectural documentation. Scenes show selections at various historical periods, graphical codes indicates genuine/former/later morphologies, justification status, object's documentation, etc.

4.2 2D SVG Interfaces

Maps are used in priority at urban scales where they enhance the readability of the urban layout. Upon selection by the user of criteria (example: all architectural objects of type "UrbanBlock" at date "1653") instances matching the criteria are selected, their XML files parsed, and a relevant SVG map is generated. The map can recursively be queried, by selection in the graphics, to get details on this or that object. Since most architectural objects are natively defined by some 2D info, we usually re-exploit a sub-set of the object's 3D morphology (a cupola for instance is defined by a radius that can be exploited in 2D). Still in cases where a calculation has to be made in order to derive 2D info from 3D info, this

calculation can be carried out at dynamic generation time within each object's SVG writing method.
A 2D SVG map corresponds to one and only one scale, which determines the objects, one can query. Switch between scales can be implemented that let the user to query the same visual sign alternatively on various levels o information.

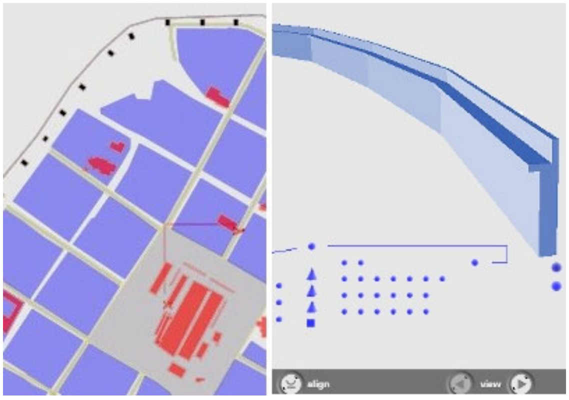

Figure 5. Example of 3D-2D derivation on the fortification wall objects.

JavaScript commands are nested inside the SVG output, which is used as one global interface, in line with the conclusions of experiences such as «Choroplethe map», provided by A. Neumann (see [Neu01]). The SVG produced does therefore not only contain the representation of the architectural objects matching selection criteria, but also includes various interface mechanisms such as inputs handling. Selection of objects inside the SVG can result in three types of events:

- PHP-driven querying of the RDBMS with XML output and online creation of a pop-up SVG window delivering data parsed from the XML.
- Direct parsing of the architectural object's XML file or of XML-based data sets (terms definitions /translations, visual material, etc.).
- Appearance selector acting on each architectural object's graphical properties.

Our 2D interfaces at this stage remain quite simple. In the actual stage of our development, they provide the following services:

- Represent and localise architectural objects.
- Retrieve each object's documentation.
- Enable visual comparisons of the values of each object's attributes.
- Generate a 3D model of the object selected.

Although 2D interfaces do provide services, they fail to address the complexity of the morphology of objects at architectural or detail scale. They are not even suitable for representing at urban scale the morphological identity of the architectural objects. This is why we believe they remain a solution that complements the 3D interfaces to which we devote the next section.

4.3 3D VRML Interfaces

Applications of the VRML standard for architectural modelling have often been discussed, we will focus its relevance in relation with our research issue. Several key aspects of VRML are exploited in our development, and some of its capabilities remain leading-edge ones with regards to *interpretative modelling* issues. The language provides features that are relevant in our context, notably its events routing mechanism that we use in order to write client-side interaction disposals that are nested inside the scene and therefore not dependant on an application or an applet. The scenes we build, support a graphical coding that allows the researcher to visualise such aspects as a comparative qualitative analysis of the documentation's content on an edifice, etc. This is done through a number of interaction disposals that are nested inside the VRML scenes and that use the values of each object's justifiers. It has to be stressed that the scenes are dynamically generated as results of user queries on the database of instances. Any change in each instance's documentation or morphology is therefore visible in the scene without any intervention.

The main families of interaction disposals nested in the VRML scenes are:

- *Highlighting buttons*: are used in order to visualise presence or not of each type of documentation (ex: inventory, architectural drawings, photographs, etc.) on each object represented in a scene.

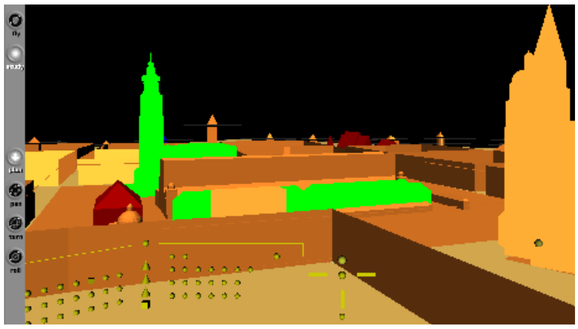

Figure 6. A visualisation of the Market Square: transparencies toggle is off, edifices with a documentation that includes hypothetical plans are highlighted, object controls and anchor selection are open.

- *Transparency cones*: are used to show on each object, how precisely it is described in the documentation. Justifier's values, initially a qualitative information, are given a numerical value that is used in order to control the object's appearance node's transparency value.
- *Viewpoint controlled actions*: actions are nested in the viewpoint list that in this case acts as a

menu, these actions toggle on and off the representation of the other controls.
- *Global scene control sliders*: provide a client-side control on ground elevation and lighting conditions inside the scene. They are called sliders since they are connected to a position tracker nested in a PROTO node, that we add to each scene.
- *Anchor selection*: provide choice of data set to be queried when a click on an object is done.

The instances and their documentation can be described independently, we need therefore to tackle two possible inconsistencies:
- An object has been instanced without documentation specification.
- The documentation has been specified but the dimensions have not yet been provided.

Two different answers have been implemented. In the case of undocumented objects, we use a particular level of transparency. In the case of an object that has been documented but for which the morphological properties were not yet given, we use a library of graphical 3D signs (see Fig 7).

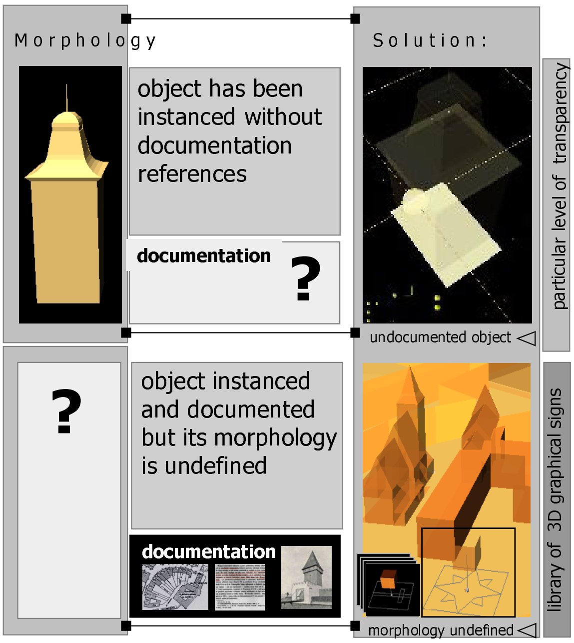

Figure 7. Stressing lacks of information.

In parallel, we have introduced timeline scenes that unlike others do not require the user to say at what date he/she queries the collection of architectural objects, but only what architectural objects he/she queries. The result of such a query is then not one morphology for each object, but several morphologies for each object representing its evolutions (see Fig 8).

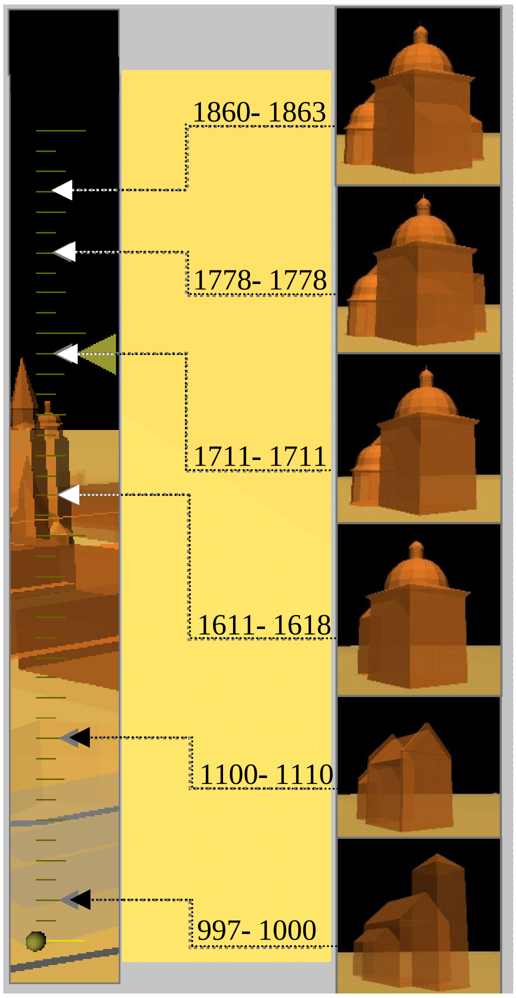

Figure 8. Timeline scene - architectural evolutions of St. Adalbert church (on the right), the timeline slider (on the left).

A specific VRML file is then created to exploit this result by providing the user with a slider nested inside the VRML scene, that controls a timeline. A PROTO node attached to each object' VRML node receives from the slider an Integer-type event that switches between various representations of the architectural object. Such scenes, besides providing an easy to read visual animation on the city's evolution, help the researcher to visualise for each object, which periods of the development are properly documented, or which morphological propositions are lacking. Timeline scenes contribute in making visible what is known and underlines what we still need to investigate.

5 CONCLUSION

The work presented in this paper clearly positions visualisation in the architectural heritage as an *interpretation*, with an ambition not for realism but for a better documentation readability and access, in line with contributions such as [Alk93] or [Kan00].

We believe that it is possible to greatly enrich the usefulness of 3D representations provided that some attention is put to the semantics behind the rendering. We propose a methodological framework in which:

- Documents are attached to architectural objects.
- Documents are critically examined on what they say about each architectural object.
- Architectural objects are formalised as concepts in a hierarchy of classes, bearing quantitative and qualitative information.
- Architectural objects are represented in dynamically generated graphics using a single XML input, and with an indication of the above mentioned documentation analysis.
- Architectural objects are represented with regards to the notion of scale, thereby introducing yet another filtering of the documentation.

Our experience in applying this framework shows that graphics in the field of the architectural heritage can *illustrate our current understanding* of architectural evolutions. They can therefore, beyond short-term seduction purposes, become a tool for scientific investigation and visualisation.

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