Using abstraction levels in the visual exploitation of a knowledge acquisition process

Iwona Dudek, Jean-Yves Blaise

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Iwona Dudek , Jean-Yves Blaise
(UMR CNRS/MCC 694 MAP, France
idu(jyb)@gamsau.archi.fr

Abstract:
Investigating the evolution of patrimonial architecture requires gathering and analysing a mass of documentary sources, the interpretation of which may authorise researchers to produce graphical simulations of the morphological evolutions of edifices. We have demonstrated that such representations can be used as graphic interfaces in which architectural objects are located in time and space. However in the field of the architectural heritage, due to the lack or incompleteness of the documentation, at the beginning of an investigation objects are often known to researchers only by their toponimical reference: their contextual names. In the early phases of an investigation process, it is most often impossible to state with any reasonable accuracy what morphology an object had. Moreover, other clues to the understanding of the edifice and its evolution, such as terminology/ontology or analogies, can be gathered by the researchers before someone actually states what morphology the object could have.
Aiming at improving the comprehension of the complex and discontinuous process of knowledge acquisition we introduce a generic formalism of information integration that lets the researchers to gather indications little by little, and allows them to follow up visually the knowledge acquisition process.
This paper introduces the use of toponymy as a start point for the analysis of the edifice, and describes the formalism we have developed in order to generalise this approach.

Key Words: Architectural heritage, Knowledge management, Interfaces, Information visualisation, Spatio-temporal data.

Categories: H.3.3 [Information Search and Retrieval] Information filtering
H.5.2 [Information interfaces and presentation] user Interfaces

1- Introduction and related works

Our field of experimentation is the historical analysis of the development of the architectural and urban heritage. This includes a concern for an edifice itself and for various documents that help to state for instance how a particular building evolved through time. In this research area, the meaning of the word visualisation is often narrowed to this of virtual reconstruction. Although 3D models that mimic reality prove relevant with respect to some popularisation goals (e.g. [Perkins (03)]), we favour an opposite approach in which what is "beyond" the image is more important that the image itself, in line with [Alkhoven (93)] for example.
What we try to visualise are not the ocular effects resembling the elements of the real world, but a transitory state of knowledge on an edifice and its evolution (see Terminology). The representations we produce are created at query time. They deliver therefore up-to-date messages about studied objects, bearing graphical indications that reveal what is known about those objects. This feature indeed relates our understanding of the word visualisation more to Bertin's view ("*…a graphic is never an end in itself: it is a moment in, the process of decision making…*") [Bertin (98)] than

to the trend of '*virtual heritage – real lies*' utterly dominant in our application field. To sum it up briefly, we consider that in the domain of the architectural heritage graphical representations should provide *visual explanation*s, using the words of [Tufte (97)], and not visual fantasies about architecture.

Related works show that 2D graphics are particularly present in site management experiences using GIS (e.g. [Sebillo (03)]). In parallel, a variety of researches on the exploitation of the SVG standard have been carried out in the recent years (e.g.[Froumentin (02)], [Jung (03)]). 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 (e.g. [Morf (02)], [Keller (02)]). Why should architectural data, spatial if one is, not benefit from these advances?

[Gagliardi (03)] indeed includes spatial search with SVG inside heritage information but the visual sign on which the search is made remains purely geographical (2D geometric concept). What historical reference mentions a 2D or 3D geometric concept? What historical information, book or painting can be attached to a geometric being?

When it comes to information visualisation, [Heinonen (00)] or [Landes (98)] 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 on the architectural objects themselves.

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* ([Göbel (03)], [Russo (01)]) or may not ([Muller (03)], [Andrews (03)]), but in all cases the graphical signs or beings have no direct relation with the information they represent: they are intermediates chosen for their readability. However the graphical signs are here usefully exploited in order to provide a semantic visualisation of information.

Investigations described by [Heinonen (00)] or [Landes (98)] and research on "3D visual metaphors" show the potential role of graphical representation in providing easier navigation and investigation tools inside information sets. They confirm that a 3D model can be an interpretation representing pieces of information - a conclusion we base on.

To say it briefly, although the content of architectural documentation is naturally space and time related (since it documents edifices or sites located at a given position in time and space) its visual interpretation and interfacing remains *terra incognita* - a question we have addressed in [Dudek (03)]. Yet it is important to note that the state of knowledge, in the early phases of research, may not allow us to provide a 3D morphology that would bear indications on what we know about the edifice we study. In other words, what graphics can we provide when we do not yet know what an edifice could be? What "*…work and discovery tool…*", using the words of Bertin [Bertin (98)], can we provide while gathering information on the edifice? We face the challenge to provide a more abstract representation of the edifice, better suited to some of Spence's views on visualisation, i.e. cognitive [Spence (01)].

In the following section, we explain the concept of toponymy used to deal with the very first stage of the information acquisition process. In the section 3, we describe a formalism of information integration we have developed to cope with various pieces

of information gathered by researchers before someone can define the edifice's morphology, and the graphics associated with it.
Figure 1 shows the variety of representations we have successively developed, and the variety of levels of abstraction they correspond to.

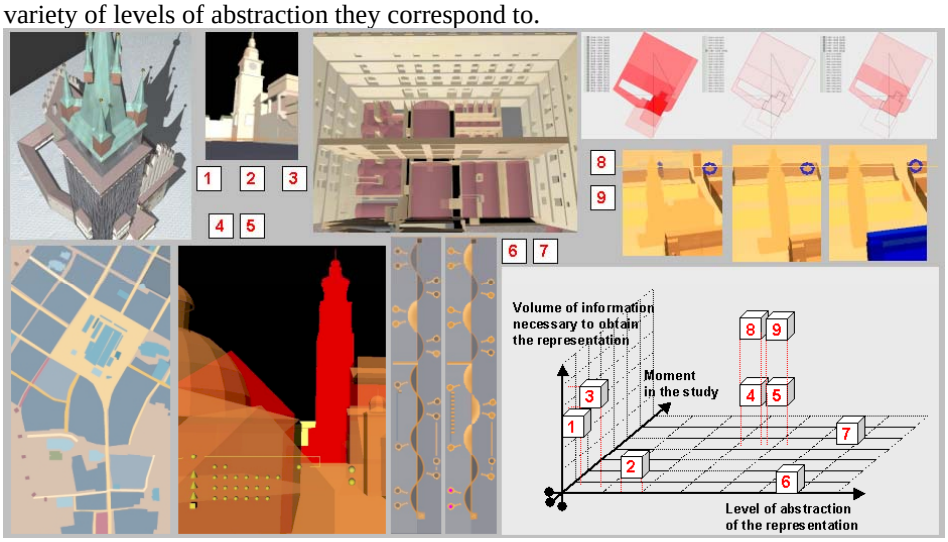

Figure 1: Alternative levels of abstraction, an example on the old town hall in Kraków. (1, 2, 3) - restitutions, (4, 5) - 2D/3D scenes used as spatio-temporal information browser, (6, 7) - diagrams showing transitory state of knowledge on the object at time T and T', (8, 9) - interactive SVG/VRML timeline disposals showing the chronological evolution of the edifice.

2- Toponymy, initial step of the knowledge acquisition process

2.1 Research question

The creation of representations in which one could graphically simulate the morphological evolution of patrimonial architecture is based on the interpretation of a mass of documentary sources most often heterogeneous and distributed. Yet, the order of appearance of the data and information cannot be foreseen: the acquisition process is irregular and remains open. This process can also be seen as the integration of specific data (documentation, archaeological findings, analogies, etc.) and of generic knowledge. Finally, this process corresponds to real-world problems that conservators or researchers face when gathering information on an edifice.
How can we provide them with a tool that would let them connect the pieces of data they gather with one another? How can we provide a visual interface that will state where we are in terms of understanding of the edifice?
In our previous contribution to I-Know KIV special track [Dudek (03)] we have discussed the use of 3D scenes composed of query-able architectural objects in their spatio-temporal context. In this experimentation, the historical data as well as their interpretations were visualised and accessed through shapes representing architectural objects (2D/3D) (see Fig. 1.4 and 1.5) – but this can be achieved, if and only if the data sets have been previously attached to those objects. Whereas in the early stages of the research process, due to the lack or incompleteness of the documentation, objects are often known to researchers only by their toponimical reference: their

contextual name as left to us through history. Researchers may know that an object *A* existed in position *P* between time *T* and *T'*, but they may not yet be able to say to what family of shapes it belongs. Still, since they are in the process of documenting the object, they need some transitional concept that would provide at least a labelled localisation in time and space.
As a possible answer to this problem, we have developed a generic model of architectural toponyms. They are structured in a hierarchy, the top of which is used in order to discriminate them geographically and the bottom of which is used in order to provide a univocal localisation of data sets with regards to objects still under investigation ("fuzzy objects").

2.2 Methodological proposal.
The historical sources vary in type, relevance and scope. They usually provides indirect indications that may let researchers state: "*something existed round here"* and reference it by a term (a church, a wooden structure, etc.) around which they can organise findings. Throughout the investigation process, information about an object is gathered, defining more precisely where the object was placed, during which period of time, etc.. At the closing stages of the knowledge acquisition process (see Terminology), proposals of detailed morphological descriptions/representations for the object may be elaborated, with qualitative indications concerning the documentary sources used as a groundwork. The knowledge acquisition process may then be represented in the following way (see also Fig.2):

Depending on the toponym's position in the hierarchy, its representation uses the geographical information (position, contour) or the architectural information (referential, 3D morphology exploited as contour in 2D or as volumes in 3D). In that sense, architectural toponyms act as integrators between geographical and architectural information, and between the scales corresponding to the various urban concepts our documentation mentions ("old town" -> geographical information, "main square" -> architectural information).

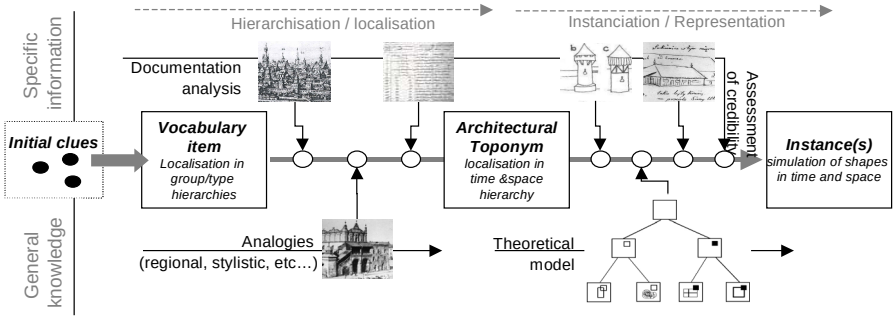

Figure 2: From initial clues to morphology simulation, food for thought in a discontinuous process.

3- Information integration in the knowledge acquisition process

3.1 Research question

The toponimical localisation we described above, and the instantiation of a theoretical model (including a thorough morphological classification) presented in [Dudek (03)] can be seen as two extremes of a line that represents the progression of the knowledge about an architectural objet. All along this line (see Fig. 3), pieces of data and information are progressively gathered constituting a current state of knowledge on the object.

In the first experimental phase, we have defined three immediate objectives:

- Integrate all data and information in a common information acquisition model.
- Provide autonomy for data/information integration since phases of study are not necessarily correlated in time.
- Implement a visualisation procedure that would show the state of knowledge of object *A* at time *T* of the study, the constitution of which is presented in Figure 3.

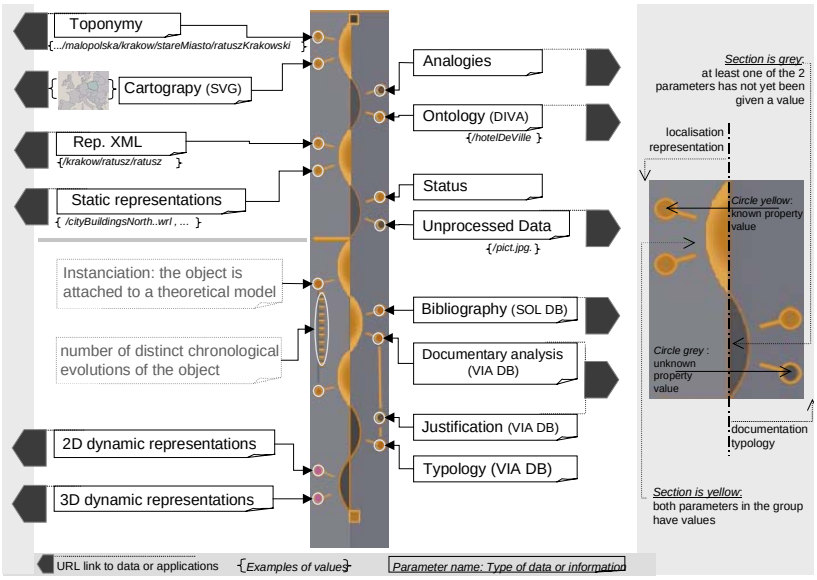

Figure 3: Parameters, or pieces of information, present in the investigation level spiral

3.2 An experimental implementation

The information integration formalism (called MIR) we have developed, is implemented practically through a set of OO classes (knowledge structure, for the main integrator MIR itself and for each sub-set like toponyms, ontologies, etc.) and through a set of applications, related to each sub-set, that exploit Web standards (XML/XSLT / visualisations VRML / SVG).

The disposal is an interactive SVG graphics thought as a spiral and represented in 2D (18 sub-sets distributed in 9 loops). Each loop represents a group of data/information varying from *general knowledge* (top) to the *detailed description* stemming from the data analyses. MIR disposal is updated automatically whenever new information is added in any of the sub-sets. Each sub-set is independent of the others, as well as of the MIR formalism (e.g. terminology, toponyms or analogies associated with an

architectural object are independent pieces of information, potentially identified out by different people). We therefore implement data structures and Web applications that let users to interact with each sub-set independently of the MIR formalism. In addition, some sub-sets (e.g. status of despair) are simple indications that do not require the development of dedicated applications. In other words we have implemented the MIR formalism using the "black box" OO paradigm: each information sub-set communicates with the MIR formalism basing on message exchanging. Coming back to our field of experimentation, as shown below on four examples, each architectural object is represented by such an information integrator that provides a synthetic view showing the pieces of information we have gathered.

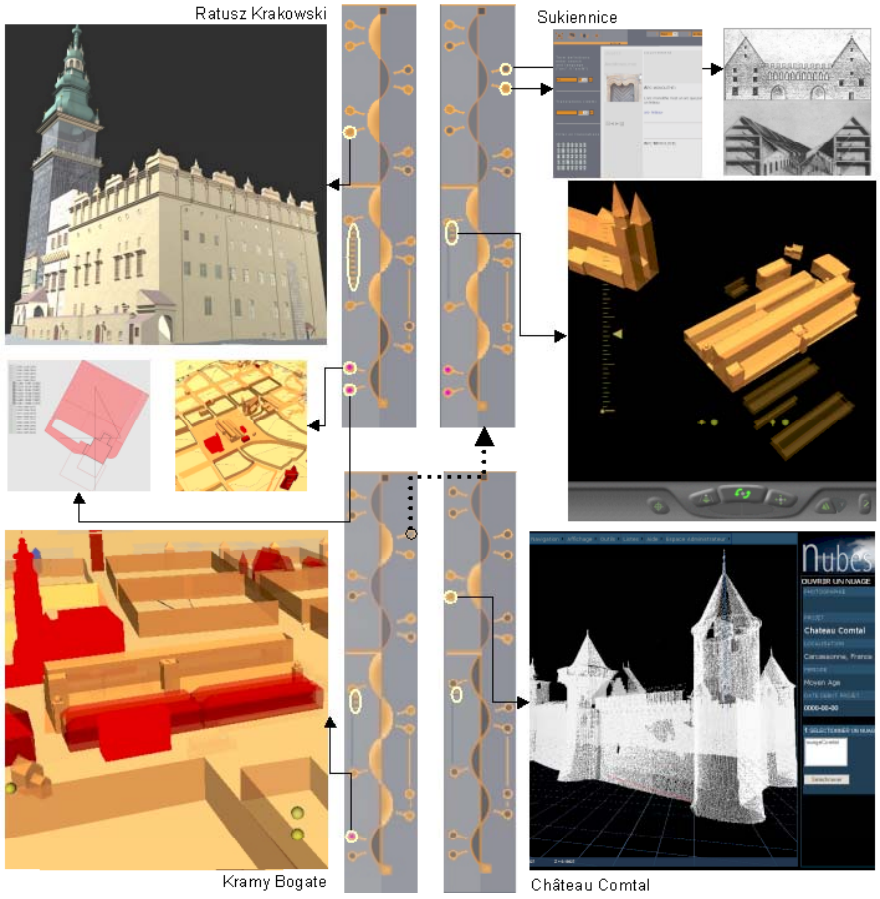

Figure 4: Comparison of four MIR knowledge acquisition spirals, corresponding to different architectural objects, and examples of retrievable data/information sets.

On Fig. 4 we present examples of indications that the proposed disposal can deliver. At the time of writing of this paper the top left and the bottom right objects are respectively the most and the least known among the ones we study - indication stressed by the colours of their spirals. Representations retrievable on the same object may vary (full restitution, MAYA™ - top left, simplified dynamic representations

(VRML) - top right and down left, cloud of points in the NUBES application, real time Virtools™ - down right). The presence of analogies and terminological information is also stressed (top right). The relative complexity of chronologies is indicated for each object on the areas circled by an oval. It is important to note that the knowledge acquisition spiral can be used as a visualisation disposal alone, but is also a navigation tool letting the user to query the various pieces of data or applications concerned (VIA, SOL, DIVA). Detailed description of these applications can be found in publications related to the ARKIW program (e.g. [Blaise (02)], [Dudek (99)]).
The proposed information integration formalism is being tested on experiments conducted in Kraków (Poland) and Carcassonne (France, in collaboration with L.De Luca). This formalism is thought to visualise a transitory state of knowledge about any architectural or urban object (a single edifice or square as well as a whole city). However one should remember that different concepts (e.g. church, town, console) relate to different levels of lecture and therefore will require different types of data. At the present state of research, we produce knowledge acquisition spirals for concepts related to one scale that can be called *urban components* (e.g. edifices, streets, urban blocs, etc.). They are calculated using the data stored in VIA, DIVA, and SOL systems (760 evolution descriptions corresponding to 329 objects, 207 resources, 820 terms with 6520 translations and approximately 4650 default 2D and 3D scenes – we did not estimate a number of representations calculated as an answer on more complex queries.). At this stage several points can already be made that underline at least the necessity to further investigate this research issue:

- A formalism adapted to a discontinuous knowledge acquisition process, and to heterogeneous pieces of data and information.
- A formalism allowing the use of alternative representation modes.
- A formalism enabling comparisons between pieces of data and information across fields of experiment.
- A visual exploitation of this formalism encompassing the whole knowledge acquisition process, underlining both what is known and what is not known.

4. Benefits and perspectives

In our experiments we have underlined the benefits of using univocal architectural objects, referenced by a term and a position, as anchors for information. We introduce the notion of architectural toponym, in charge of a transitional localisation of pieces of information in time and space. In a generalisation effort, we introduce an information integration formalism that lets researchers gather and visualise various clues they unveil on the evolution of edifices. It appears as a possible contribution to solving problems raised by numerous authors (e.g. [Alkhoven (93)], [Barceló (02)]) on the knowledge acquisition and representation process in the field of the architectural heritage. Further experimentation end evaluation of the method we propose will focus on concepts of different scales, with a focus on enhancing the readability of the produced graphics.

Acknowledgements

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Terminology

'A state of knowledge about an object' should be understood here as a systematically organised collection of *objective* and *objectivised sentences*, as defined by [Bocheński 92)]. In this context 'knowledge acquisition process' stands for the process of adding new objectives and objectivised sentences to the existing collection.
an objective sentence – the meaning of the sentence;
an objectivised sentence – a sentence represented by the use of signs, so it is understandable to other people;

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