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Section V - Theory and Practice in Conservation of Architectural Monuments, Historical Ensembles and Sites

IT applications for architectural intervention and documentation in monuments' ensembles

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Abstract

Concern for the architectural and urban preservation problems has been considerably increasing in the past decades, and with it the necessity to investigate the consequences and opportunities opened for the conservation discipline by the development of computer-based systems.
Architectural interventions on historical edifices or in preserved urban fabric face conservationists and architects with specific problems related to the handling and exchange of a variety of historical documents and representations. The recent development of information technologies offers opportunities to favour a better access to such data, as well as means to represent architectural hypothesis or design. Developing applications for the internet also introduces a greater capacity to exchange experiences or ideas and to invest on low-cost collaborative working platforms.
In the field of the architectural heritage, our research addresses two problems:
historical data and documentation of the edifice,
methods of representation (knowledge modelling and visualisation) of the edifice.

This research is connected with the ARKIW POLONIUM[1] co-operation program that links the MAP-GAMSAU CNRS laboratory (Marseilles, France) and the HAiKZ Institute of Kraków's Faculty of Architecture. This joint research programme is dedicated to the documentation of edifice's evolutions basing on the modelling of relevant fields of knowledge.

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Scope and objectives

The GAMSAU CNRS laboratory (Marseilles, France), specialised in the use of computer techniques, and the HAiKZ institute of Kraków's faculty of architecture, specialised in conservation, have initiated a joint research programme, named ARKIW, focusing on IT technologies as a mean for distant exchange and updating of research work on architectural artefacts. This multidisciplinary programme, leaded by *Prof. A.Kadłuczka* and *M. Florenzano*, investigates a field of knowledge (the architectural heritage) and a knowledge representation formalism (Object Orientation) in order to produce an outcome: an interdisciplinary representation of the artefact's evolutions. Several fields of experimentation have been chosen in the historical centre of the city of Kraków (Poland).
In this section we will introduce the basic ideas and positions we are taking. In the following section we will discuss the problem of classifications as a reasoning mode for the organisation and the identification of the architectural model (or structured corpus). We will then present two specific tools and with them an application of this very architectural model to the representation of reconstructional hypothesis and to the interfacing of a resource database.
In a multidisciplinary approach of the architectural heritage the historical, archaeological (…) data to handle features texts, maps, iconography, etc… Moreover, theses sources are detained by diverse institutions in which classifications of the data is generally author-based even though they may concern individual buildings, urban fabrics, or themes related to their making. Specificity of this data to handle is its connection to a localisation in the city and to a historical period (re-uses, evolutions or destruction of a building).

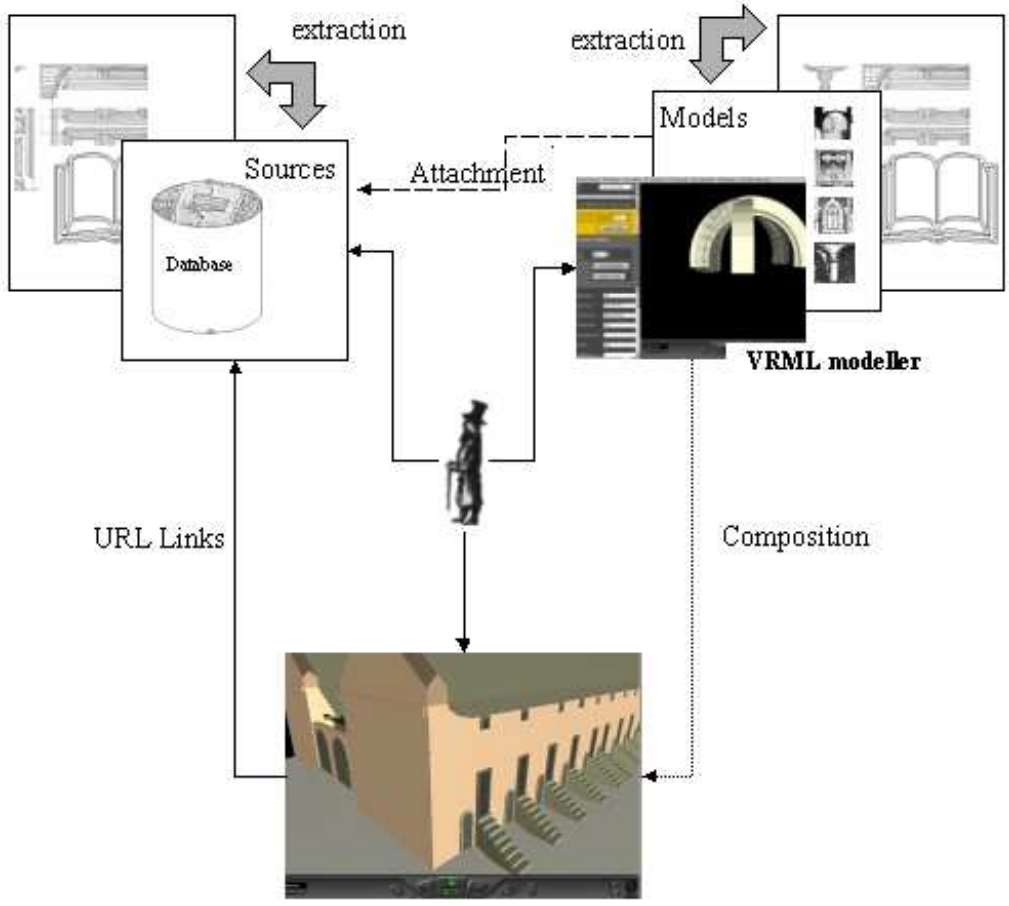


Figure 1: Sources, models, VRML interface and the database: basic principles of the development

The development we present (http://alberti.gamsau.archi.fr) uses a http protocol centred architecture connecting a relational database, a VRML 2.0 representation module and a web search interface. It is experienced on the urban fabric of the Rynek Główny in Kraków showing both existing and destroyed buildings. It allows searches and updating of the database through a standard text based interface, a VRML 2.0 graphical module for which an on-line modeller has been developed, and a thematic search interface.
The system will gather, with the successive contributions of students or researchers, a large quantity of 3D-localised information that will be connected to each building concerned, and that will serve as a support for further studies. By enhancing access to past researches and providing day to day updating, it favours a renewal of multidisciplinary researches and approaches of the architectural object.
The global disposal we propose includes:

i. A vrml architectural Modeller
ii. A resource database
iii. Database internet interfaces among which VRML models

Our position is that the 3D representation of an artefact's corpus can greatly favour the readability and the accessibility of related data on the condition that this representation shows architecture more than geometry. In other words, we believe that a 3D representation using a predefined architectural model can ease the construction of a building-centred heritage information system.

Classifications and the architectural model

A broad area of research has been opened in the past decade on object orientation as an implementation of the reasoning by classifications paradigm. In Architecture, theoretical classifications can be dated back to the work of the roman architect and theorist Vitruvius who analyses edifices both in terms of composition and in terms of morphologies. He organises individual elements of the corpus inside stylistic classes [Vitruve, 1988]. His approach has set a strong methodological background for the theorists of architecture throughout the classical period. A major ambiguity however appeared on which concepts should be organised: physical objects or spaces they enclose and their purpose [Fichet, 1979]. Social division lines tended to replace or complete morphological division lines as proven by Serlio's theoretical work [Cuisenier, 1991].
The works of Viollet Le Duc in the nineteenth century, both as an architect and as a writer, strongly reintroduce morphology and structure of the edifice in its analysis [Viollet Le Duc, 1977]. By doing so, the architect brings to the fore the idea that physical objects can be considered as basic concepts to deal with when studying patrimonial edifices. We consider that object orientation provides a relevant formalism in representing the corpus of physical objects [Florenzano et al, 1997].

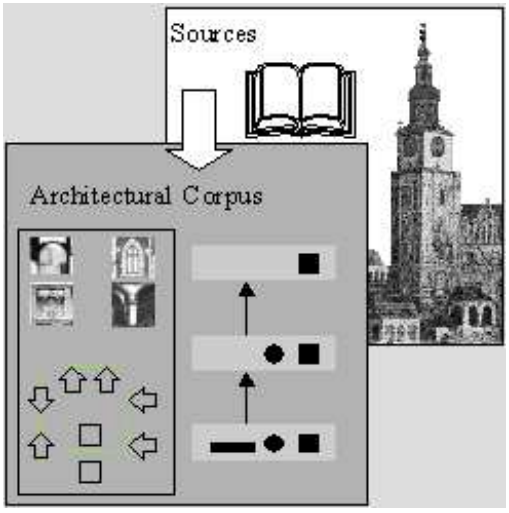


Figure 2: The architectural model

Classifications of such elements along with a non-ambiguous definition for each concept involved, such as those provided by [Pérouse De Montclos, 1988] and [Tajchman, 1989], are the guidelines we use.

Basing on the relevant sources, we analyse the edifice as a composition of individual physical objects that we call entities.
Elements of a building will be described as *entities* providing that they meet three requirements:

i. An entity is a unique "object " identified by a single element of the vocabulary.
ii. An entity has an obvious role in the physical structure of the building.
iii. An entity intervenes independently of any other in the building's system of relations.

Architectural *entities*, structured by the inheritance of class mechanism are analysed from the point of view of intention. This means isolating object categories for which similarities of structure or behaviour can be observed.
The architectural heritage however clearly reveals elements of permanence and of variability, the knowledge to be represented and handled features both stable concepts (the roofing, the opening, etc.) and their historical variations or local interpretations. Attributes introduce here a level of generality in the morphological definition of the entity (profile handling for instance) that provides degrees of freedom inside the definition of an entity.
An entity as defined above has a morphology that is represented for instance in VRML. But the entity also includes non-geometrical information (bibliographical sources, etc.) that will be conveyed inside the representation (for instance URL or queries inside the VRML scene).
In OO languages, a class (i.e. concept) is a text including properties and methods [Ducournau et al, 1998]. In our case, properties correspond mainly to the morphological specificity of the entity and methods to its interfaces (for instance VRML format writing). We gather generic objects into hierarchies of elements. Each property added gives a birth to a new, more specialised, element, placed lower in the hierarchy [Florenzano et al, 1997].

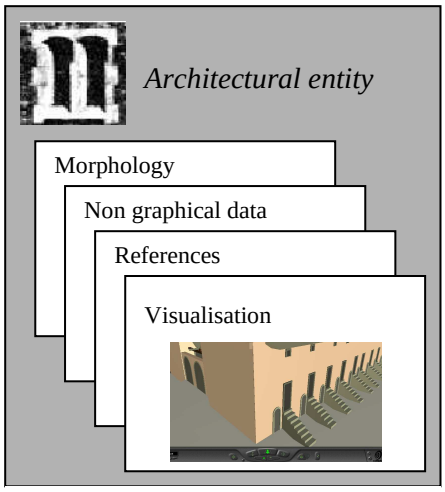


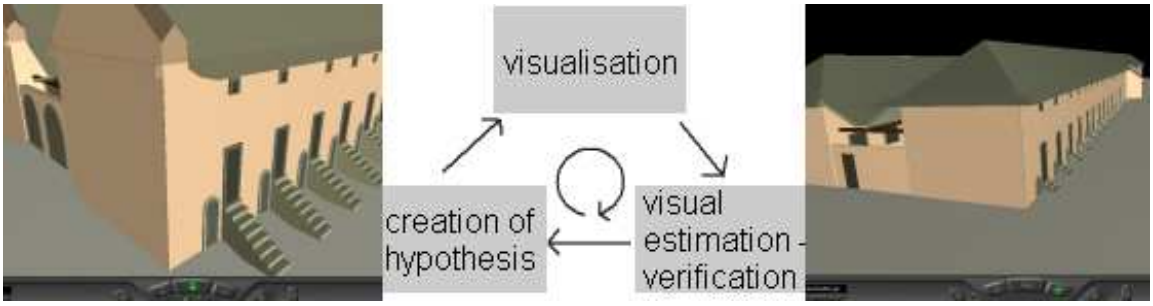
Figure 3: The architectural entity, a multi-layer concept.

We are therefore given a formalised knowledge (corpus of entities) and its sources (a bibliography). In the next section we will see how modelling scenes using this knowledge is allowed, and how connecting the model featured in the scene with non-graphical data is possible.

VRML modelling

Architects, historians of art, archaeologists and other professions that deal with the architectural heritage frequently face objects partly or totally destroyed [Łukacz, 1998]. Most commonly destruction is the effect of time passing, but also of fires, floods, wars as well as ignorance or irresponsibility. A detailed documentation that would provide information about form and structure of a despaired object is often lacking.
Therefore any reconstruction either purely theoretical or aiming for rebuilding or adaptation of the remains has to be based on comparisons and analogies. Creation of a hypothesis, as an act, is the result of an author’s expertise. The next necessary step is a visualisation of the proposal in a perceptible form, its correctness and probability can then be verified by a visual estimation. This verification process is repeated until the satisfactory proposition is formulated.
Visualisation is a most tiresome and time-taking element in this process, it is therefore important to provide researchers with a knowledge-based tool that could help in authenticating, through the step of visualisation, the entire process of hypothesis building.

VALIDEUR is the name we have given to the VRML authoring tool, based on our architectural model, aimed at enabling visual verifications of reconstructional hypothesis.



Objective of the VALIDEUR tool is to provide an Internet interface for on-line creation of VRML scenes in which each object represented is an instance of the architectural model. In addition, access is given to non-graphical data including a URL used in order to query the resource database described in the next section. VALIDEUR uses two main hierarchies of classes: architectural classes and interface classes.

Each element of the architectural classes hierarchy detains properties and methods inherited from the Entity class (top of the hierarchy).

This shared definition includes:

- Bounding box dimensions
- Level of detail / of definition and Material / lighting information (VRML features)
- A co-ordinate system used for positioning objects inside the array
- A member of the Interface hierarchy

Each element of the architectural classes hierarchy also detains specific properties and methods:

- Specific morphological properties
- VRML scene appending method
- IN / OUT methods

The interface classes hierarchy handles the actual writing of each entity's description inside standard HTML forms. In addition to those two main hierarchies of classes, geometrical classes

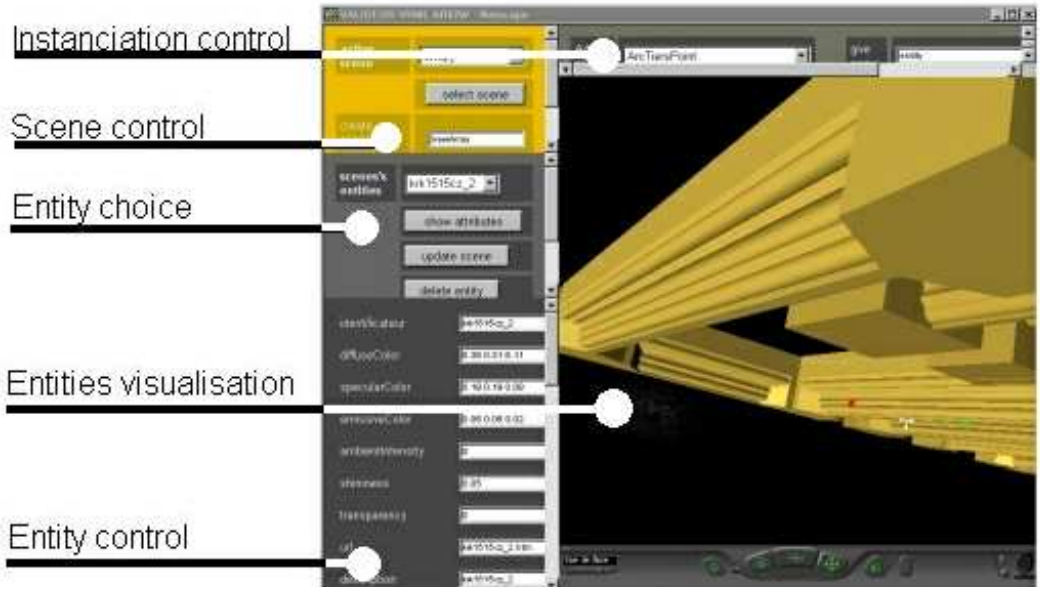


Figure 4: the VALIDEUR interface

provide tools for the representation of profiles for instance, and the array class handles the processing of VRML scenes computation.

The interface illustrated on figure 4 gives access to the morphological definition of the entity, to its localisation inside the array (scene) and to VRML-specific properties such as colours,

lighting, etc. Default values, stored in template objects at system level or scene level, are assigned to new instances of the architectural objects.
Organisation of the objects in the scene, up to handled by positioning the object's co-ordinates system, is to be handled by choosing among relations of composition used in the vocabulary of architecture such as plumb with, etc.
As shown on Figure 5, the VRML description of each entity includes a generic section inherited from the Entity Class and a specific section in which only the entity's morphology or it's attributes morphology is written.
This introduces a new idea: morphology for attributes. But why do we need a morphology for attributes when we already have one for entities?
As previously mentioned, Elements of a building will be described as *entities* providing that they meet three requirements (unique form, unique function, independence).
From this definition we derive that profiles or more generally elements of decoration are not relevant in isolating new classes of entities. With whatever profile a regular beam has been carved, it is still an instance of the beam class, with a unique VRML representation method. We have in accordance with the theoretical work of [Tajchman, 1989] developed a generic formalism for profile handling in which the *rhythm* of the profile is given as a property of the entity, and in which its *morphology* is generated so as to fit the entity. As it is a rule in patrimonial architecture, profiles are specified in 2D in relation with their type (fillet, ovolo, etc.) and control points specify curve inversions.

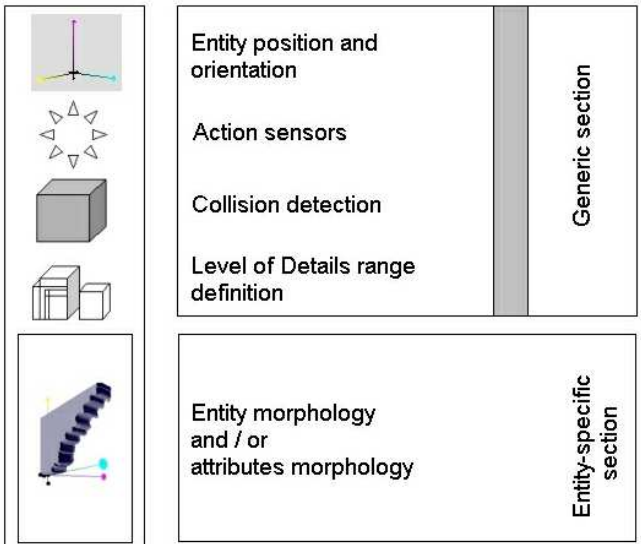


Figure 5 : generic and specific sections of the entity's VRML representation

VALIDEUR is a VRML collaborative modeller using an underlying architectural model that can be seen as an object-oriented typology library, and is in keeping with current researches on web collaborative platforms and VR in architecture such as [Oxman, 1999] and [Roberts, 1999]. It however is dedicated not only to the representation of hypothesis but to connecting a 3D VR model to its genesis.

Resource database

SOL (Sources On Line) is a bibliographical, iconographical and cartographic database search tool for the web, accessible from any computer connected to Internet. It references data connected to the urban fabric of Kraków's Main Square (Rynek Główny) or to problems related to the architectural conservation and protection discipline. As an addition to standard bibliographical data identification (author, edition, etc.), it features additional information, or "dedicated points of view" for each source. This mechanism connects each entry to data concerning for instance building considered, architectural detail, historical period mentioned, etc. Specific query interfaces (textual, cartographical, 3D) allow the questioning of each point of view. Since its relevancy relies on the researcher's analysis of references, such a tool can prove useful only if it mirrors the constant evolution of his sources. An updating web-based interface is therefore proposed in order to allow distant interventions on the database itself. In addition, the VRML authoring tool presented above gives an opportunity to figure different moments of the site as well as different hypothesis on these moments. On one hand, references in the SOL

database are books, researches, papers, etc. On the other hand, our program is about urban fabrics, architectural objects, and their evolution. A strong requirement for the system is therefore to connect both inside the data sheet itself and in the query interface the fist to the second. This means providing the data sheet with morphological-oriented information for instance, and retrieving it through a graphical localisation interface.
Another strong requirement for the system is to allow through the updating interface not only the addition or modification of entries, but also an interaction with the "dedicated points of view". Adding criteria is implemented so that new building-specific problems (e.g. "the ave-bell of the old town hall", "the ceiling morphology of the cloth hall", etc..) , new generic theme (e.g. "wood roof covering" in materials and techniques thematic group) can be added to the system. This requirement corresponds to the necessity to encourage a collaborative construction both of the database's contents and of its search criteria.

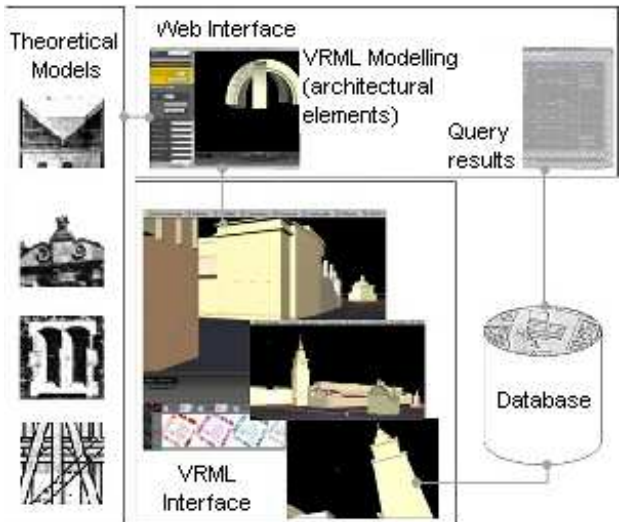


Figure 6: principles of the linkages between the VRML scenes and the Database

Principles and development of the SOL tool are more thoroughly discussed in [Dudek et al, 1999]. The VRML scenes constructed using VALIDEUR are naturally the basic entry points in questioning SOL on architectural entities. In other words, the 3D representation of an architectural hypothesis, in accordance with figure 1, features knowledge on the model (the architectural corpus) and on its sources (the database).

Conclusion

The analysis of the architectural and urban evolutions of Kraków's Main Square is today a crossing point for historians, architects, archaeologists, etc. We believe that it is essential in the field of the architectural heritage to use VR and web technologies in order to better interface representations of hypothesis and their sources. This approach can be seen as applying GIS principles at architectural scale on 3D models, and a recurrent research theme (see for instance [Whiting et al, 1997], [Ioannidis et al, 1999], [Alkhoven, 1993]). Our results show that such an objective is today widely within reach. Since Christopher Alexander's pattern languages the fields of architecture and computer science are known not to be opposites. Moreover, the field of the architectural heritage can benefit from the raising awareness of conservationists that computer techniques can favour the readability of their researches.

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