JAVA COLLABORATIVE INTERFACE FOR ARCHITECTURAL SIMULATIONS

A case study on wooden ceilings of Kraków

Jean-Yves Blaise
Architect, research engineer MC

Dr. Pierre Drap
CNRS researcher

gamsau UMR MAP 694
Ecole d'Architecture de Marseille-Luminy
184, av. de Luminy 13288 Marseille Cedex
09 France
Tel 33 4 91 82 71 70 Fax 33 4 91 82 71 71
email. (Jean-Yves.Blaise, Pierre.Drap)
@gamsau.archi.fr
http://moma.gamsau.archi.fr

Iwona Dudek
mgr inż. architekt

Instytut Historii Architektury i Konserwacji Zabytków
Wydział Architektury
Politechniki Krakowskiej
ul. Kanonicza 1,
31-002 Kraków, Poland
email. idu@gamsau.archi.fr

This article shows a part of the results of co-operation between the GAMSAU CNRS laboratory (Marseilles, France) and the HAiKZ Institute of Kraków's Faculty of Architecture realised in frames of the ARKIW program.
The French co-ordinator of the program is M. Florenzano
The Polish co-ordinator of the program is Prof. A. Kadluczka
other researchers involved in this part of project: Dr Marek Łukacz

Abstract

Development of net-based tools initiates a new architecture-computer science junction, offering a possibility to investigate distant exchange and updating of research work on architectural artefacts.

Dealing with conservation in architecture, photogrammetry and computer science our research meets the stakes of multidisciplinarity. Moreover, The heterogeneous technical systems and tools met in the scope of these disciplines clearly call for a platform-independent tool that would give an access to the patrimonial information gathered. Web interfacing is an answer to this problem, it is the central development presented in this paper.

Questions addressed in this paper are object oriented knowledge modelling in the area of conservation, web-interfacing and the application of the abovementioned items to a first case study - a simulation tool for the wooden ceilings of Kraków.

Foreword

Concern for the architectural and urban preservation problems has been considerably increasing for more than a century. The recent developments of information technologies and their use in the field of conservation now address the key issue of how to enable collaborative work between the various specialists involved.

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 research and exchanges program, named ARKIW, dealing with this question. This co-operation program, leaded by *Prof. A.Kadłuczka* and *M. Florenzano*, focuses on the architectural patrimony and on the elaboration of a knowledge tool using the architectural model as the core of an interdisciplinary representation.

Our main objective is to bring out a computer platform that would let researchers to manipulate theoretical architectural models, used for example to simulate archaeological or architectural hypothesis. Therefore, relevance of this interdisciplinary approach relies on the *ability* of a computer-based system to convey within the simulation process the whole information it detains (historical, architectural, morphological, etc.).

This initiative corresponds with a need of facing conservationists expertise that is noticeable in the domain of computer science and in the same time it gives opportunity for conservationists to add new tools to their work.
The three main topics will be discussed in this paper:

- *Knowledge representation in computer science*

  The architectural patrimony clearly reveals elements of permanence or of variability within the architectural language. The knowledge to be represented and handled features both primary concepts of architecture the roofing, the opening, etc. and their historical variations. A relevant answer to a question of how to deal with this issue is offered by the object oriented approach in computer science which enables a description concepts stemming from the phenomenon to be studied through a semantic hierarchy.

- *Web-based distributed interface*

  Providing a distant, platform-independant access interface to the architectural models appears as a strong necessity. The distant collaborative interface that has been developed proposes iterative action on script editing (for instance describing a reconstructional hypothesis) and on visualisation of reports.

- *An experimentation on a set of architectural objects: the case of the wooden ceilings*

  The ARKIW programme deals with questions related to the representation of architecture in the computer science discipline, with a special interest on the process of evolutions of buildings. The main objective of the research is to favour a global understanding of the architectural evolution of Cracow's Old Town Hall (*Ratusz Krakowski*), and to enable the representation of reconstructional hypothesis. This presupposes a thorough investigation of each of this evolution's steps in order to identify and organise sets of non-ambiguous *objects* (i.e. primary concepts of architecture). A first case study has been chosen in order to experiment the web collaborative interface: the case of wooden ceilings.

Background of the research

The MOMA research programme (**M**odels and **O**ptical **M**easurements in **A**rchitecture) developed at the GAMSAU CNRS laboratory is focused on the field of architectural surveying (photogrammetry, knowledge representation) as well as on the domain of the architectural heritage (identification of pathologies , simulation of hypothesis).
Taking advantage of the consistency of object-oriented programming with complex knowledge, the project can be described through three phases :

- Formalisation, measurement processing, and information of the architectural model.
- Representation and implementation of hypothesis.
- Platform-independent web interfacing of the research outputs.

The survey process developed in MOMA makes use of photogrammetrical survey techniques to propose a method that integrates a pre-defined knowledge of the elements to be measured. The survey process first gives dimensions to the independent elementary entities, using canonical definitions of the models involved, then makes use of one or more hypothesis on their combinations so as to link them to one another. The ARKIW program gives an opportunity to experiment this approach on complex architectural objects.

Experiments of the MOMA process have been previously carried out. They have proved the feasibility of the approach. However, it is clear that researchers involved in the drawing-up of archaeological or architectural hypothesis are not always specialists of computer science. As a consequence of this fact for closer co-operation between computer science specialists and conservationists or archaeologists the recent developments in our research have been focused on the interfacing of the process, in order to easen its access for non-specialists. This way our developments offer an opportunity of a direct intervention on the architectural models for non-specialists in computer science.

Object Oriented approach applied to conservation

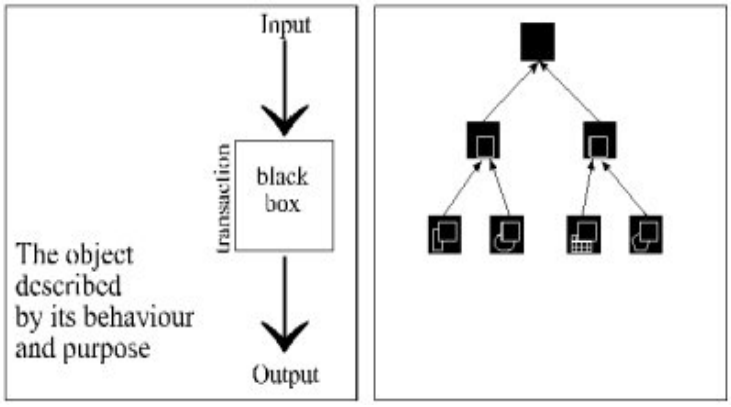
The architectural patrimony is described according to two major principles :

- Splitting the building into elementary, univocal objects, that we call architectural entities. The entities are organised with the help of relations stemming from the architectural vocabulary (perpendicularities, relations to an axis, topological behaviours, ...)
- Building restitution methods that allow the representation of diverse hypothesis when given a single set of entities, concerning the manner with which they were organised and composed.

Architecture is therefore considered as a non-ambiguous mean to federate information both on morphological aspects and on other aspects.

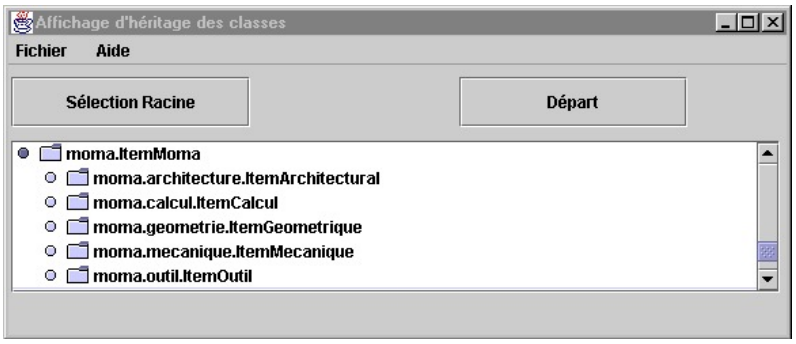
Principles:

Natural history stands as a paradigm of the object-oriented approach in knowledge representation. Individuals are gathered into species sharing their specificities. Families sharing common behaviours or properties are gathered into families that share these specific behaviours or properties. The Vertebrate family for instance shares one common property: having a backbone.



Fields of knowledge involved

The object-oriented programming languages give an opportunity to formalise and handle models of complex knowledge fields. The field of knowledge is split into elementary concepts structured through refinements of classes. The object-oriented programming approach lets us gather generic objects into hierarchies of elements that share common properties, behaviours or attributes. Each property added gives a birth to a new generic element that is more specialised - that's why it is placed lower in the hierarchy. Our research incorporates diverse fields of knowledge represented in the tree of classes shown aside.



The Architectural classes

Architectural concepts are described as entities, arrays, attributes and relations and are gathered in the ItemArchitectural hierarchy.

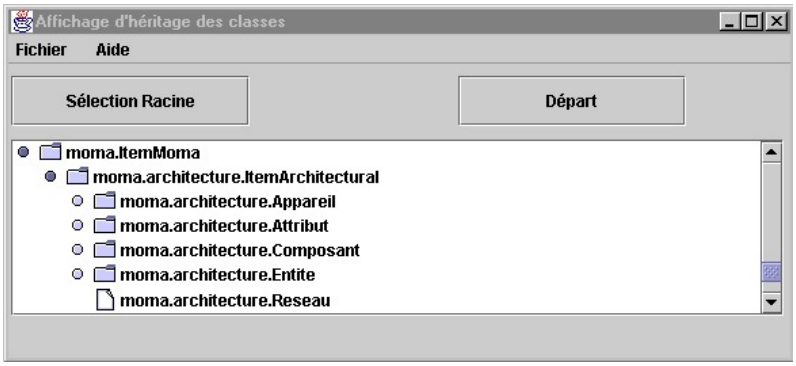
Elements of a building will be described as *entities* (elementary components) providing that they meet two requirements (conditions for *entities*):

- An entity is a unique " object " identified by a single element of the architectural vocabulary.
- An entity has an obvious and permanent role in the physical structure of the building.

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. Once the properties of the architectural entity are described (both nature and behaviour) the relations between entities are formalised in order to organise the building.

Arrays are groups of entities and relations chosen in order to represent one specific combination. Typical example of arrays is any type of the Roman or Greek column. They consist of generally three entities aligned according to each order's rules (base, shaft, capital).

Attributes are items of vocabulary that correspond to morphological specificities of one or several entities, serving as tools in their definition or representation.



The definition of a scene : script language

A script defines how a given set of entities is organised in an array, and visualised in a scene.
The vocabulary used in this **script** corresponds to the architectural entities and their relative positions.
Regner (Chapiteau1, Chapiteau2) ;
Au Droit (Fut1, Fut2, y, 1.230) ;
Aplomb (Chapiteau1, Fut1) ;
Percer (Mur1, Baie1) ;
are four valid phrases of the grammar, where :

- *Regner* corresponds to a common altitude of the entities involved
- *Au Droit* corresponds to a common axis of the entities involved in plan, with a parameter stating the distance between them.
- *Aplomb* corresponds to a common vertical axis of the entities involved.
- *Percer* corresponds to the performing of openings inside a wall entity.

The model corresponds to a current state of the knowledge, meaning that it figures its certainties as well as its remaining elements of uncertainty. It therefore allows the representation of several hypotheses. The flexibility of the model's description permits also the representation of the evolution of knowledge related to a building, or of the evolution of the building itself.
The use of CAD tools forbids any omission on the morphological model. The whole of the dimensional data has to be informed and the final model ensures a consistency of the entities never mind what accuracy and complexity their definition takes. Given data on an urban fabric our approach gives way to an evolutionary model taking into account advances in the fields of conservation, archaeology or history. A restitution of an urban fabric at different points is thereby possible, showing stages in its growth. The final model has educational features that can be targeted at non-specialised publics.

Interfacing the models

Facing requirements of multidiscplinarity

Our research is targeted at diverse users: researchers in computer science and disciplines related to architecture (close-range photogrammetry, conservation, education) and PhD students. All developments of our research use the JAVA web-enabled Object Oriented language. This new technical choice gives a possibility to propose a collaborative platform meeting three requirements:

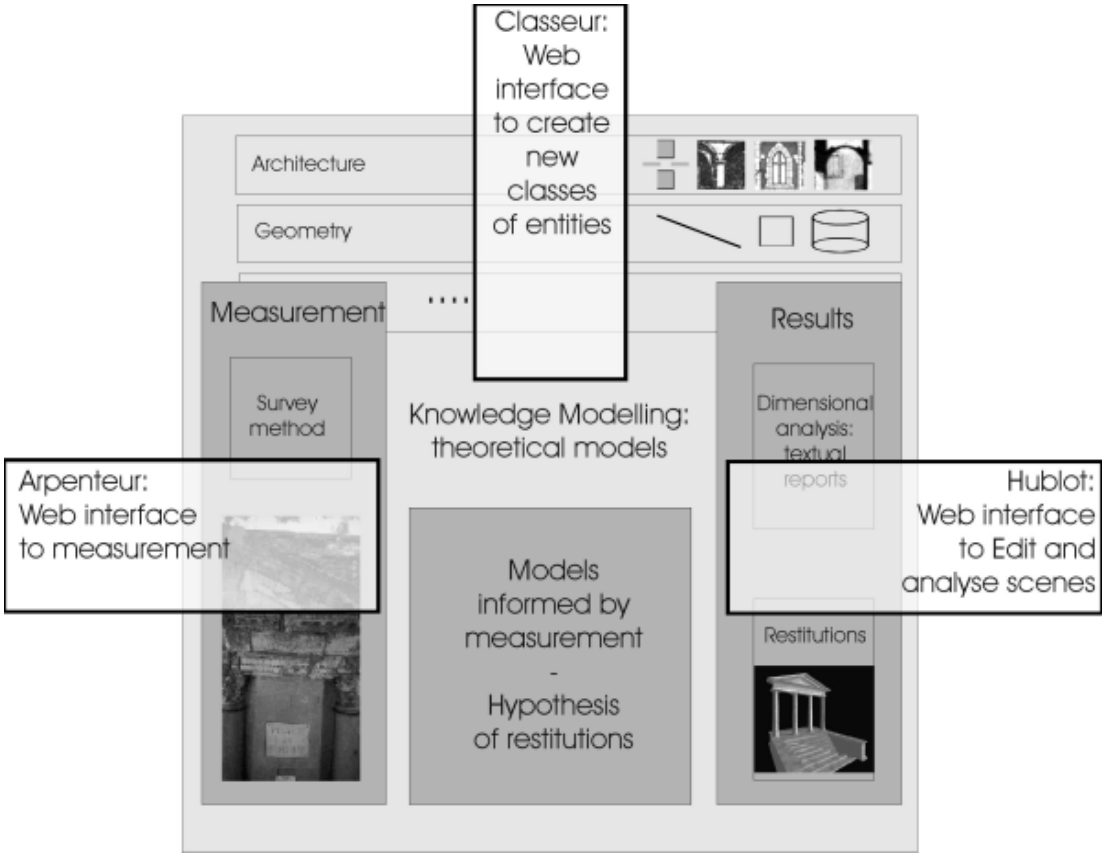
- distant access (definition and modification of scenes, interaction with the architectural model, access to the survey process)
- platform independence (the interface is available on all net-enabled computer systems)
- ease of use for non-computer scientists

The web as a collaborative platform

Three tools have been developed in order to monitor the different uses of the model:

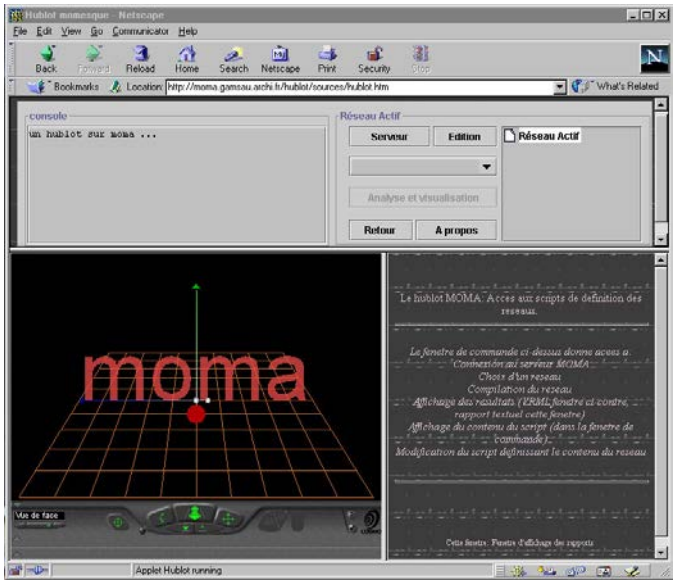
- Arpenteur - a web-based photogrammetric survey tool
- Classeur - JAVA development enabling the creation of new classes of entities added inside the model
- Hublot - a results interface that gives an access to the textual reports and VRML visualisation of the arrays of entities

The diagram shown below sums up the different interfaces developed in order to let researchers to interact with the model (inputs and outputs).



An experiment on the Hublot interface:

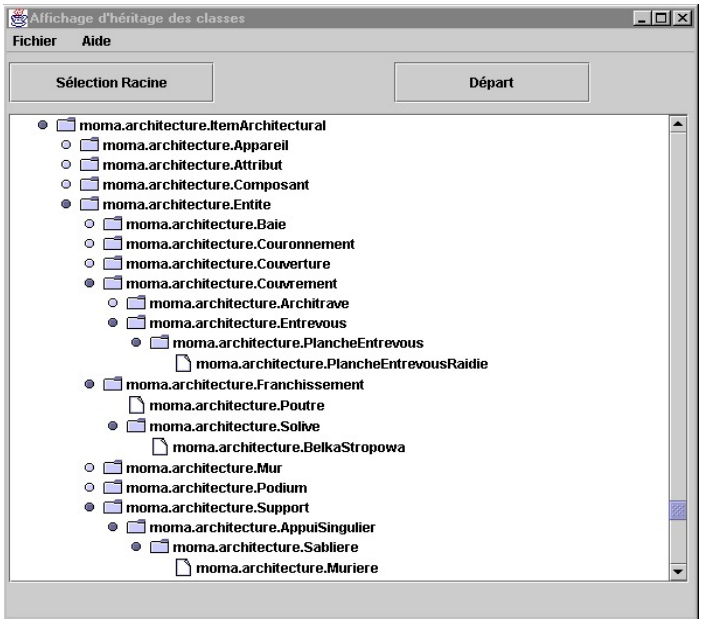
The Hublot interface is dedicated to the edition and analysis of scenes on-line (groups of entities and relations). As will be shown in the case study to follow, this interface lets a researcher to interact with the MOMA models (create his own set of entities) on different levels:
The levels are as follow:



- addition or subtraction of entities in a array (specific combination of entities and relations)
- addition of sub-arrays (combination of arrays)
- modification of each entity's features like position, dimension, orientation, etc...
- on line computing and visualisation of the results in VRML (Virtual Reality Modelling Language, an interactive platform-independent 3D scene definition language)
- on line computing and visualisation of the textual reports in HTML (listing the characteristics of each entity in the scene)
- connection between the two types of results (results in VRML and HTML)
- computing of a drawing file that can be used in MicroStation (a CAD tool)
- iterative action on each of these levels

Case study: wooden ceilings of Kraków

A short introduction to wooden ceilings of Kraków

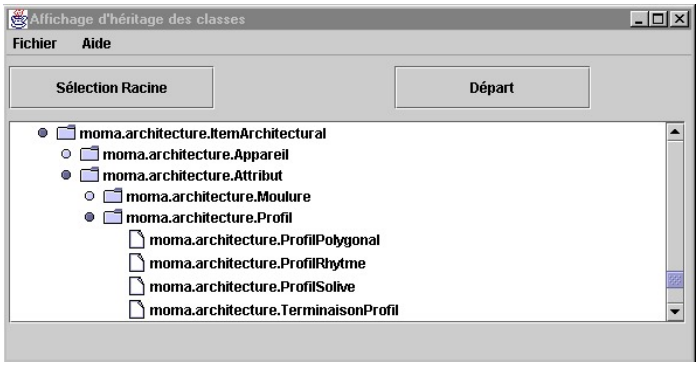


The wooden ceilings of the urban houses of Kraków where chosen as a case study for the abovementioned interface. Our analysis of the corpus of elements involved in the construction of wooden ceilings is based on the thorough analysis proposed by Jan Tajchman. A strong support was brought to us in this work by dr M. Łukacz from Institute of HAiKZ (Department of Architecture, PK).
This reference work presents a clear classification of the different types of ceilings together with their a description of the elements intervening in their construction.

Our task was therefore limited to an analysis of the data in order to classify elements of the corpus either as entities or as attributes.
Showing and making clear the specificity of such a corpus strongly calls for the 3D manipulation tool. The VRML 3D visualisation offered in the Hublot interface is therefore highly welcomed.

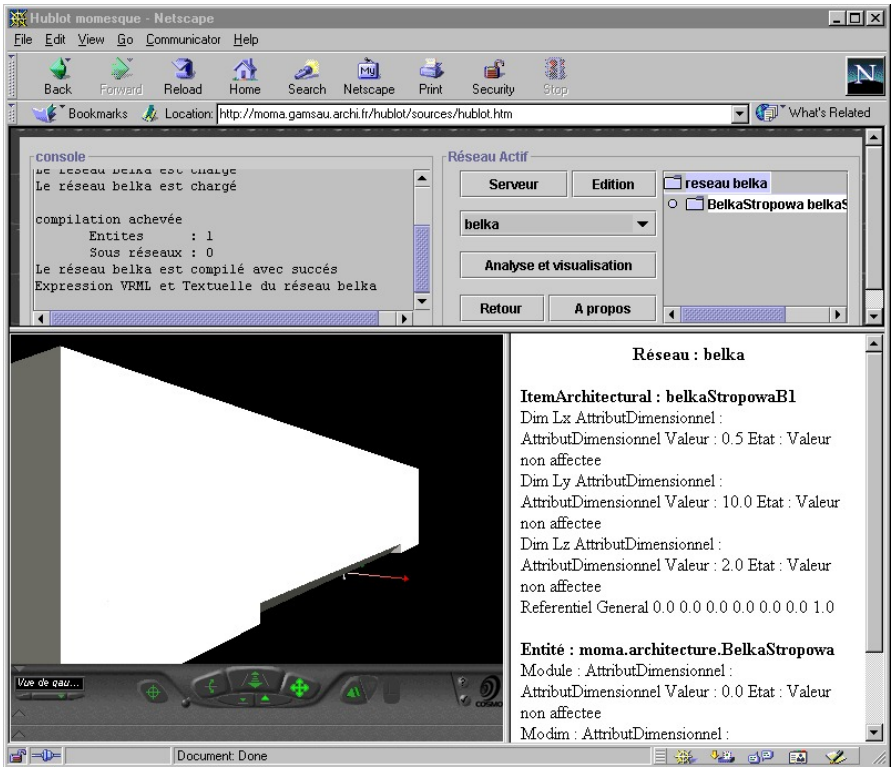
Description and Classification

The subsequent phase was an analysis of the elements intervening in the definition of a wooden ceiling . This phase means isolating entities and attributes according to the MOMA's methodology presented in chapter one. An abstract of the hierarchy of classes proposed is shown on the diagram below.



Interaction with the models

The Hublot interface lets user to create arrays (scenes) of entities. In the ceiling experiment a test array has been implemented and is shown in the diagram below. New arrays can interactively be created. Each array contains a set of entities positioned, oriented and dimensioned in the script. Manipulating the elements of a ceiling then means modifying the script and launching the analysis and visualisation process.



Conclusion and developments to come

Recent developments in the fields of knowledge representation and network tools arise wide opportunities for new multidisciplinary collaborative approaches of patrimonial studies. The major stake in this research is the development of a model federating the multidisciplinary knowledge related to the architectural heritage. Initial outcomes have focused on the analysis of the domain and gave way to web-based developments enhancing collaborative work between researchers involved.
We have consequently focused on web interfacing in order to provide a platform-independent access to the underlying models.

The research continues with a focus on the object oriented formalisation, used in order to formalise the heterogeneous data encountered in the architectural field. This approach of the architectural heritage opens up researches aiming at the definition of new building analysis tools (development of a data management system dedicated to the architectural heritage, representation of reconstructional hypothesis, network platform developments).
Didactic access to patrimonial data should now be developed through a VRML-JAVA-OODBMS integrated system.

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