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Iwona Dudek, Jean-Yves Blaise

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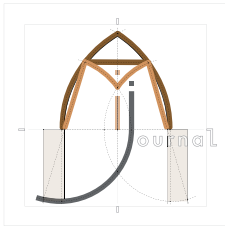
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Actes de l'Ecole Thématique

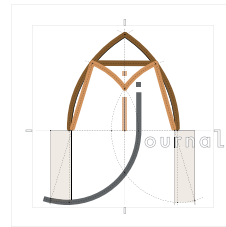
Modélisation Informationnelle pour l'Architecture patrimoniale

Proceedings of the International Workshop

Informative Modelling for the Architectural heritage



Saint-Maximin la Sainte-Baume, 2006



Vol.0, n°1

Actes de l'Ecole Thématique
Modélisation Informationnelle pour l'Architecture patrimoniale
Proceedings of the International Workshop
Informative Modelling for the Architectural heritage

Saint-Maximin la Sainte-Baume, VII-2006



CENTRE NATIONAL
DE LA RECHERCHE
SCIENTIFIQUE

UMR CNRS/MCC 694 MAP

Modèles et simulations pour l'Architecture, l'urbanisme et le Paysage

Préface / Preface

Ce premier volume du journal MIA, journal que nous espérons voir s'inscrire dans la durée, est consacré aux contributions des intervenants et participants à l'école thématique « Modélisation Informationnelle pour l'Architecture patrimoniale ». Cette école, organisée du 4 au 7 juillet 2006 à Saint-Maximin la Sainte-Baume, à l'initiative de l'UMR CNRS/MCC 694 MAP, porte sur une démarche émergente, appelée modélisation informationnelle, qui se situe à l'intersection des sciences et technologies de l'information et de l'analyse multi-échelles du bâti (depuis l'architecture urbaine jusqu'au corpus de l'édifice).

Démarche méthodologique, la « modélisation informationnelle » fait le pont entre le domaine de la modélisation spatiale proprement dite (représentation géométrique, multi-représentations, multi-résolutions, etc.) et celui de la visualisation d'informations au sens d'E.R. Tufte, c'est à dire une démarche d'explicitation visuelle.

L'école thématique a pour objectif général de mettre en partage, d'évaluer, de structurer et de pérenniser cette thématique et au-delà de rassembler des compétences pluridisciplinaires autour des questions scientifiques qu'elle pose. Elle est organisée dans un lieu d'histoire riche et complexe, l'ensemble basilical de Saint-Maximin la Sainte-Baume. Le programme pédagogique fait largement appel au monument et à son histoire comme support pédagogique à part entière, soit comme objet d'observation, soit comme objet de confrontation entre formalismes et réalités pratiques. Le thème de l'école et le lieu dans lequel elle se tient sont donc associés : le second devant rendre tangible tant les questionnements soulevés que les avancées attendues sur le premier.

Parce qu'elle est fondamentalement pluridisciplinaire, la thématique de l'école méritait d'être abordée depuis des points de vue différents : les actes de l'école, rassemblés dans les numéros 1 et 2 du présent volume, traduisent au delà de nos espoirs initiaux cette complexité. Nous espérons que le journal MIA, initiative lancée à l'issue de cette école thématique, saura être un lieu où des scientifiques d'horizons différents veillent à faire de cette complexité non plus un écueil, des barrières entre disciplines, mais des complémentarités, des ambitions communes au service de l'étude et de la défense du bâti patrimonial, notre héritage, notre legs.

This first volume of the MIA journal, a journal that we hope will be continued, is dedicated to the proceedings of the MIA (Informative Modelling for the Architectural heritage) International Workshop (4-7 VII 2006, Saint Maximin la Sainte Baume, organised by the MAP research unit).

The workshop's theme, informative modelling, is an interdisciplinary approach, linking information technologies with multi-scale analysis of architectural artefacts (ranging from urban forms to architectonic details). Informative modelling defines a renewed methodological framework aiming at a better understanding and documenting of the evolutions of heritage sites, with a focus on new challenges for graphics (realism vs information, simulation vs authenticity, ..). The idea behind informative modelling is to try and bridge the gap between architectural representation, with a tradition of figuration, and information visualisation, with a necessity of abstraction.

The workshop and tutorials should lead to the structuration of a scientific community gathering people from various disciplines who already face the questions raised by this research theme. The event will take place inside a remarkable heritage site, the basilical ensemble of Saint-Maximin la Sainte-Baume. Classical in morphology, yet complex in terms of history, the edifice(s) will be the support of various modules (tutorials), thereby giving the audience an opportunity to switch from theory to practice iteratively.

Because the workshop's theme is a truly interdisciplinary one, the workshop's theme deserved to be addressed from various point of view: these proceedings go beyond our expectations, with a variety of contributions that clearly show that heritage architecture can be at a crossroad of scientific disciplines. We expect the MIA journal, launched as a continuation to the workshop, to be a place where specialists from various disciplines may have an opportunity to cross-examine fruitfully their experiences, in order to foster a better understanding and preservation of heritage architecture.

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Table des matières / Index

<i>Wolfgang KIENREICH</i> Information and knowledge Visualisation: An Oblique View	7
<i>Renato SALERI</i> Expériences au laboratoire ARIA	19
<i>Jan TAJCHMAN</i> The systematics of historic wooden floors with no plastered ceilings encountered in Poland	27
<i>Alberto SDEGNO</i> Between Design and Survey: Interpretative Problems in the Study of Drawings for Digital Modelling	39
<i>Stefano SPACCAPIETRA, Christine PARENT, Esteban ZIMANYI</i> The MADS Data Model Concepts to understand the structure of your spatial or temporal data	51
<i>Paolo SALONIA, Antonella NEGRI</i> Cultural Heritage: surveying, integrating heterogeneous data and sharing knowledge over the Web	65
<i>Antonina ŽABA</i> On basic perspective system of illusionistic-architectural vault painting	81
<i>Marta MAREK</i> Reconstruction numérique de l'aménagement historique de Cracovie Projet réalisé au Musée Historique de la Ville de Cracovie	93
<i>Francesca DE DOMENICO</i> De l'acquisition des données spatiales à la représentation architecturale: le cas des vestiges du théâtre antique d'Arles Principes pour un système d'informations architecturales 3D	105

<i>Patricia ALKHOVEN</i> Less is more. Visual truth and the benefits of abstraction in 3D	117
<i>Livio DE LUCA</i> Relevé et multi-représentations du patrimoine architectural Méthodes, formalismes et outils pour l'observation dimensionnée d'édifices	131
<i>Jean-Yves BLAISE, Iwona DUDEK</i> Modélisation informationnelle: concepts fondamentaux. Visualiser pour raisonner sur des connaissances architecturales. 14 règles plus une	143
Liste des auteurs / Author index	155

Information and Knowledge Visualisation – An Oblique View

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During the last two decades, Information Visualisation has become a major focus of activity in the area of computer science. Researchers from many fields discover Information Visualisation as a valuable tool for analysis and manipulation of a wide range of information spaces. Unfortunately, identifying a range of visualisation methods suitable for a specific task is not a trivial problem. This contribution focuses on the importance of considering the combination of formalisms, metaphors and models to be employed in designing visualisation systems. Some modern information and knowledge visualisation systems are presented and classified into a scheme according to usage of these fundamental units of visual representation. Conclusions are drawn towards the importance of preceding algorithmic and technological decisions in visualisation design with an analysis of formalisms, metaphors and models required for a given problem domain.

Information and Knowledge Visualisation, User Interfaces, Computer Graphics

H.5.1 – Multimedia Information Systems

H.5.2 – User Interfaces

1 – Introduction

Information Visualisation, the use of computer-supported visual representations to aid understanding of abstract data, has been an active and expanding field of research for over two decades. Historically rooted in early attempts to visualise numerical information using non-electronic media, Information Visualisation has thrived with advances in the graphical capabilities of computers. Several applications of Information Visualisation attracted public attention (compare Note 1) and increased commercial and research interest. With the advent of the Worldwide Web, Information Visualisation gained importance as a tool to access and analyse massive online data sets. Modern visions of a Semantic Web[2] imply visual means for exploration and navigation which are based on Information Visualisation methods and will define future challenges for the area.

Today, Information Visualisation as a discipline has reached a stage of development where sub-areas start to emerge which differ significantly in information base, algorithmic approach and application area. Proponents of such sub-areas often find themselves tasked with the challenge of choosing an optimal combination of visualisation approaches for a problem. Given the distinct focus of the field on information technology, it is tempting to make such a choice along technological axis. In this publication, it will be argued that the more fundamental decision on the balance between visual formalism, visual metaphor and visual model, based on the application context and the information space underlying a problem, is vital and should precede technical considerations. A brief introduction to some visualisation systems and an attempt to classify these system by use of formalism, metaphor and model will be used to convey the argument and to provide some hints for researches tasked with designing visualisations for unconventional problems.

Note 1. Information Visualisation first attracted public attention in 1986 when, in a terrible accident, the Space Shuttle Challenger disintegrated shortly after launch. As Edward R. Tufte describes in one of the standard readings on Information Visualisation [1], data suggesting the imminent failure of the technical components responsible for the catastrophe had been available. However, due to poor visual representation, the engineers charged with evaluation of launch readiness failed to perceive the problem.

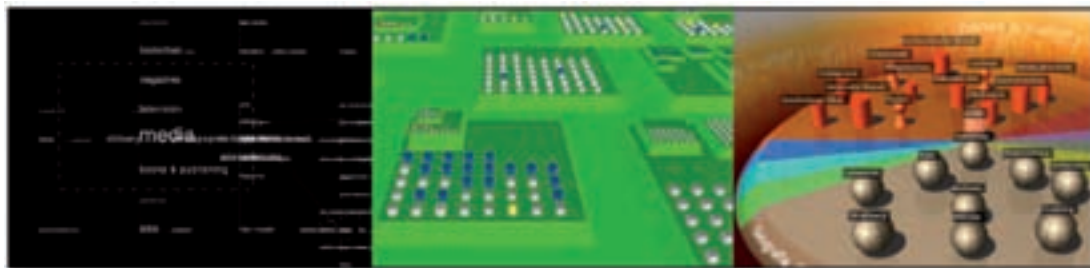


Fig. 1. Information Visualisation history. From left to right: Visualisation of news articles (1994)[3], visualisation of directory structures (1997)[4], Visualisation of Encyclopedia Knowledge spaces (2005)[11].

2 – Visualisation

Visualisation can be described as the use of visual representations to aid in analysis of quantitative or qualitative information. Starting with historical efforts to annotate geographical or celestial maps, various attempts at visualisation are documented (compare note 2). Modern visualisation systems rely on real-time computer graphics and diverse input devices to display interactive representations of complex information spaces.

2.1. Information Visualisation

Information Visualisation is commonly defined as the use of computer-supported, interactive, visual representations of abstract data to amplify cognition. Based on the observation that the human visual sense is capable of rapid perception, transformation and classification of information, work in the field literally tries to enable “the use of vision to think” [5]. Beside the dedication to computer-supported methods, Information Visualisation is distinguished by a clear focus on abstract information and on information seeking. Some key insights gained in the field are perhaps best described by the “mantra of visual information seeking” as stated by Ben Shneiderman: Overviews first, zoom and filter, and details on demand [6].

2.2. Knowledge Visualisation

Contrasting the focus of Information Visualisation on large information spaces and individual information seeking, the comparably new field of Knowledge Visualisation focuses on the transfer of knowledge among persons [7]. Knowledge Visualisation often works on smaller, but highly organized sets of information and employs multiple complementary visualisations which convey different aspects of a common knowledge space.

2.3. Visual Analytics

Jim Thomas, one of the founding fathers of the field of Information Visualisation, describes Visual Analytics as “the formation of abstract visual metaphors in combination with a human information discourse that enables detection of the expected and discovery of the unexpected within massive, dynamically changing information spaces”[8]. Powered by the increasing integration of data mining technology and information visualisation methods, visual analytics is commonly perceived as “the step beyond information visualisation”, especially in the US based research community. Motivation for work in the field stems from application areas like homeland security or genetics.

Note 2. Displaying several variables which determined the outcome of Napoleon’s 1812 invasion of Russia in a single image, the flow chart created by French historian C. J. Minard is a famous early example of what today would be called Information Visualisation.

3 – Methodologies

Analysis of methodologies used in the design of visualisations is often based on technical considerations because of the strong focus on information technology exhibited by the dominant field of Information Visualisation. However, before considering the technological realisation of a visualisation, a more basic decision must be made regarding the representation form to use. Three fundamental units of visual representation are available to a designer: Formalisms, metaphors and models. Most visualisation tasks require a carefully balanced mix of these three units based on characteristics of the information to be conveyed and of the expected group of users to yield a successful visual representation [9].

3.1. Formalisms

Visual Formalisms employ diagrammatic visual representations to display information in an abstract way. The semantics used by a visual formalisms are explicitly determined by a designer based on requirements implied by the information which is to be displayed. For example, normalized quantitative data could be represented in arc segment form, with a full circle denoting a value of one. As the designer is free to adapt the formalism to peculiarities of the underlying information, formalisms can be defined for most application cases. However, users of a formalism must explicitly learn the semantics underlying the visual representation and adapt their mental models accordingly. This cognitive translation process can be tedious and error-prone in the case of complex formalisms.

3.2. Metaphors

Visual Metaphors use a form of visual representation based on a real-world equivalent to display information. The semantics used by a visual metaphor are implicitly determined by the real-world equivalent. For example, a landscape metaphor displaying two discrete information entities in spatial proximity implies a close relation between the entities. Consequentially, a designer has to make sure that a given metaphor is able to convey all relevant aspects of a information space before using it in designing a visualisation. Users of a metaphor do not have to learn all the semantics underlying the visual representation: Drawing analogies from the real-world equivalent enables intuitive understanding of the information underlying the visualisation. Note that this both implies that the designer takes care to closely match the visualisation to the real-world equivalent and that users are familiar with the metaphor chosen.

3.3. Models

Visual Models are applied in cases where the information to be presented is itself based on a real-world equivalent, which then can be said to be the natural form of representation. For example, geospatial information can be presented in the form of a three-dimensional model, a visualisation which is both implied by the information and easily recognized by the user. Unfortunately, many information spaces are not based on direct real-world equivalents, and even in cases where information originated from such equivalents, additional requirements of the representation often severely restrict the usability of a visual model. Considering the case of visualisation in the context of architectural heritage, a visual model is seemingly a logical form of visual representation. However, a large number of factors (for example change over time, uncertainty in information available, additional information to be conveyed) render the a realistic and meaningful visual model next to impossible.

3.4. Diversity

It is hard to imagine an application of visualisation which requires the sole use of one of the fundamental units of visual representation described. In most cases, the mixed use of formalisms, metaphors and models will be required. Usually, one master visualisation (compare Note 3) will be employed which conveys the most important aspects of the information space in question. This master visualisation will be accompanied by additional visual representations of potentially different type, which transport further properties of the underlying information space.

A master visualisation is most easily chosen if an information space is based on real-world equivalents. In such cases, according visual models offer themselves as a natural form of representation. When information spaces are of a more abstract nature, designers try to find a metaphor which conveys a maximum number of properties of the underlying information space, and use this representation as the master visual representation. Supplementary visual formalisms can then be derived to represent additional information not yet covered. Visualisations where the master visual representation is based on a formalism are notoriously hard to interpret for users in all but the most simple cases, like charts or numerical diagrams.

Note 3. The notion of synchronised multiple views describes approaches where multiple master visualisations are defined for a single information space. Usually, each visualisation in a multiple view system is tailored towards one aspect of the information space. In the context described here, each visualisation in a synchronised multiple view system can be considered one master visualisation.

4 – Case Studies

This section introduces several visualisations which use visual formalisms, metaphors or models in various forms and combinations, in a broad spectrum of application contexts. Each visualisation is briefly presented and evaluated for its use of the three fundamental units of visualisation representation.

4.1. Directory and Document Visualisation

The InfoSky visual explorer [10] is a system enabling users to interactively explore large, hierarchically structured document collections. Similar to a real-world telescope, InfoSky employs a planar graphical representation with variable magnification. Documents of similar content are placed close to each other and displayed as stars, while collections of documents at a particular level in the hierarchy are visualised as bounding polygons. The underlying data source is assumed to be a hierarchically structured document repository, with documents having significant textual content. A patented algorithm exploits hierarchical structure for performance optimisation, generating a similarity-based 2D-layout for millions of documents in thousands of collections. InfoSky employs a visual formalism inspired by the idea of an interactively zooming galaxy of stars, organised hierarchically into recognizable thematical clusters. While it has been claimed that the visual representation used by InfoSky employs the night sky as a metaphor, in the context of this publication it is more correct to use the term of visual formalism due to the high amount of abstraction present in the representation.

4.2. Encyclopaedia Visualisation

„Brockhaus Enzyklopädie“, the most prestigious German language encyclopedia, has recently taken first steps towards employing ontological structuring in the organisation of its articles: A knowledge map is present for most articles, which relates an article to a score of similar articles and provides a quantification of the degree of relatedness. While not an ontology in a classical sense, the knowledge map of an article allows quick identification of related content, and navigation can be used to browse a domain of knowledge. The Gyro visualisation system[11] employs a turntable metaphor to present users with a threedimensional representation of the knowledge map. Various visualisation channels like color, shape and size are used to convey as many aspects of the underlying knowledge objects as possible. A metaphorical approach has been chosen in designing the visualisation of Gyro because on one hand, no real-world equivalent to inter-article similarity is available, and on the other hand, the comparably low number of knowledge objects did not require a complex formalism.

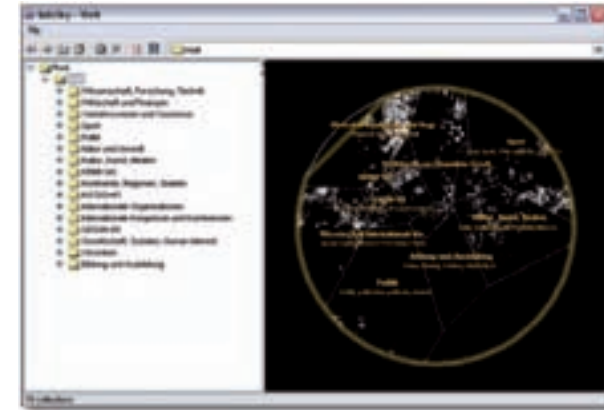


Fig. 2. The InfoSky Visual Explorer: Visualising large, hierarchically structured document repositories.

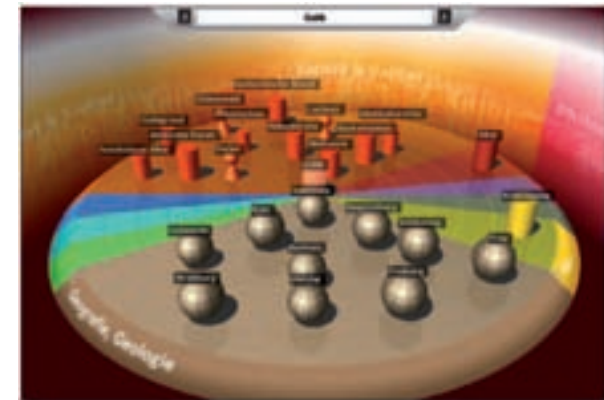


Fig. 3. The Brockhaus Encyclopedia 3D Knowledge Space: Visualising Encyclopedia articles, context and structure.

4.3. Web Search Result Visualisation

Today's web search engines return very large result sets for query formulations consisting of few specific keywords. Results are presented as ranked lists containing textual description of found items. Such representations do not allow identification of topical clusters, and consequentially make it difficult for users to refine queries efficiently. WebRat[12] is a multipurpose retrieval and visualization framework enabling users to formulate queries against any number of configured data sources (i.e. indexing services, web search engines, intranets etc.). Returned query results are then merged, clustered and visualised with labels describing the most obvious clusters of found documents to allow easy query reformulation and refinement.

Visual representation takes the form of islands on a virtual satellite map which are labelled with the according keywords. The concept of the visualisation is simple: Documents with similar content are placed closer together, and islands appear where there is a concentration of closely related documents. The visualisation is incrementally updated as results arrive from configured sources. Users can zoom in and out on the map, revealing more details or displaying an overview in the process. Labels are also calculated on the fly, accordingly, to always describe the most obvious concentrations of documents or, in terms of the visual representation, the biggest islands. WebRat has been applied in the context of web query refinement, environmental information retrieval and search engine result evaluation and comparison.

4.4. Architectural Heritage Visualisation

Visualizing information on architectural heritage sites is a task which goes far beyond the obvious. For a given architectural artefact, a visual model based on a three-dimensional rendering seems to be the natural form of visual representation. However, especially in the case of architectural heritage sites featuring a long documented history, there is so much additional information available on each element of any conceivable three-dimensional representation that the visualisation in its basic form actually hides the underlying semantics. A large number of supplementary metaphors and formalisms is required. Informative modelling has been proposed as a methodological approach aiming at the integration of artefacts modelling with information visualisation [13], with the ultimate goal of create meaningful visualisations for complex architectural information spaces.

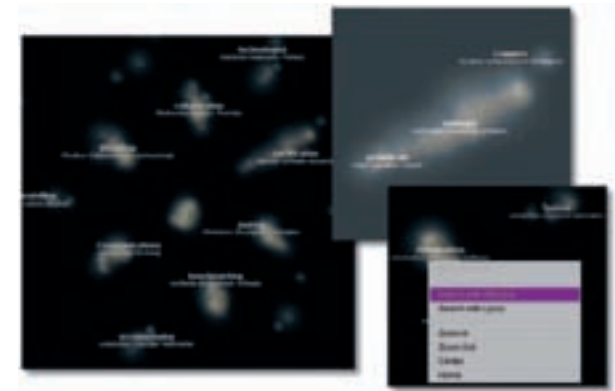


Fig. 4. WebRat: Visualising web search results.

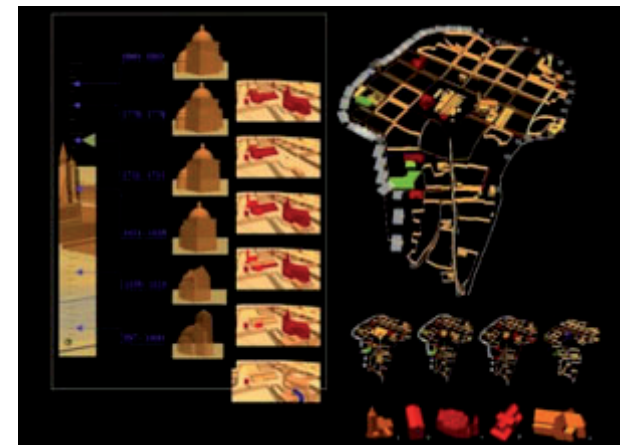


Fig. 5. Informative Modelling: Representing and studying Architectural Heritage in a visual environment.

4.5. Geospatial Visualisation

Geospatial anchoring can be defined as the process of attaching information entities, for example articles from an encyclopaedia knowledge space, to named geographical entities as provided by a world map [14]. Anchoring of articles may occur based on various types of geospatial references made within article content. The Brockhaus Web Atlas is an implementation of an architecture enabling geospatial anchoring of the articles contained in the “Brockhaus Enzyklopädie”, the most prestigious German language encyclopedia, to a worldwide geographic information system. A web-based atlas client application cooperates with the web-based version of the Brockhaus encyclopaedia and employs geospatial anchors to enable browsing of encyclopaedia content by geographical context. Similar to other recently published map systems, the atlas client supports free navigation of Earth’s surface up to very high magnifications, based on satellite image and altitude data. Various dynamic map overlays provide additional geographical, morphological, political and miscellaneous information.

The Web Atlas clearly uses a visual model to represent the underlying information space and reinforces the model character of the visualisation with various physically incorrect but visually appealing effects like moving clouds and background star fields. Future challenges based on peculiarities of encyclopaedia articles may well lead to the inclusion of additional visual metaphors or formalisms: For example, it is not clear how time-dependent geospatial anchors can be displayed in the real-world equivalent model.

4.6. Astronomy Visualisation

Based on experiences made in design and implementation of the Web Atlas, an extension of the concept of geospatial anchoring to astronomical entities is currently under development [15]. Figure 6 shows a screenshot of the astronomical equivalent of a geographic information system: A space atlas containing the planets and moons of the solar system as well as distant stars, galaxies and other deep sky objects. While a visual model seems to be an intuitive visualisation approach for the task, first results indicate that many supplementing metaphors will be required to transport the wealth of information available on celestial objects and to make comprehensible real-world properties, for example distances and brightness values, which are very hard to visualise. The space atlas, named “Brockhaus Planetarium”, will be available in future electronic editions of the “Brockhaus Enzyklopädie”.

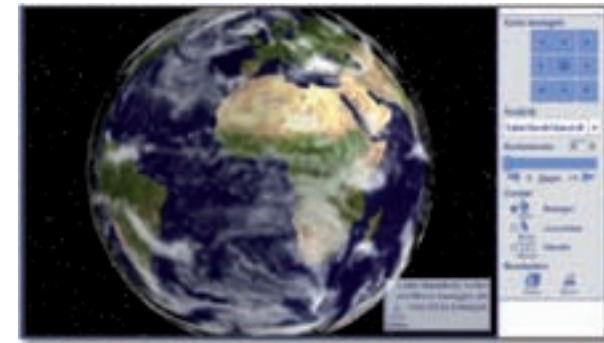


Fig. 6. The Brockhaus WebAtlas: Visualising geospatial data and related Encyclopedia information.



Fig. 7. The Brockhaus Planetarium: Visualising astronomical data and related Encyclopedia information.

5 – Classification

The visualisations presented in the previous section can be obviously classified in a scheme distinguishing by use of formalism, metaphor and model. Visualisations of highly abstract information spaces, like directory structures or content-based inter-article similarities, tend towards the use of formalisms due to the lack of any suitable real-world equivalent, while visualisations based upon real-world data, for example of geospatial or astronomical nature, clearly benefit from a model-based approach. However, when much information is available beyond the real-world equivalent, as in the case of informative modelling or astronomical data, the master visualisation used has to be extended by metaphors or formalisms as explained in section 3.4. This observation leads to a second aspect relevant for a classification scheme of visualisations: How many additional units of visual representation are required to convey the whole of the information space available, and of which type are these additional units? When making design decisions in regard to visualisation systems, it seems recommendable to find visual representations for all relevant aspects of the underlying information space and then to choose the master visualisation in a way which minimizes the number of diverse, additional visual representations required, according to the scheme displayed in Figure 7. This contrasts conventional approaches which focus on the use real-world equivalent models if at all available.

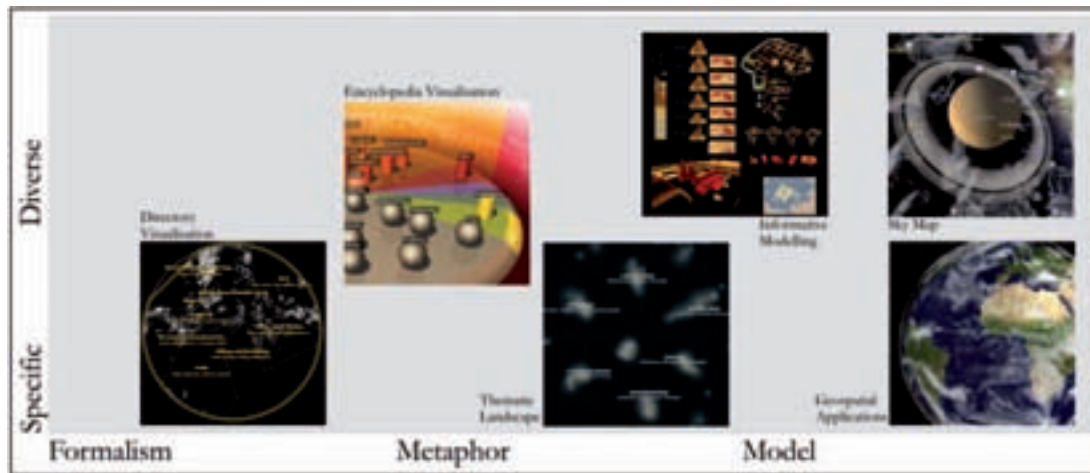


Fig. 8. Classifying visualisation approaches: The vertical axis denotes diversity of visualisation means used, the horizontal axis denotes the type of the core visualisation used.

6 – Conclusions

This contribution has briefly presented several modern information and knowledge visualisation systems. It has been demonstrated that all visual representations used by the systems described can be classified by their use of visual formalisms, metaphors and models. All of the systems have displayed a certain degree of diversity in their use of these fundamental units of visual representation. In each case, a master representation could be identified which tended to convey as much properties of the underlying information space in a single view. Supplementing the master representation, further visualisations were usually included, which transported additional information not easily expressible in the master representation. The type of visualisation used for the master representation, together with the diversity of these supplementary visualisations, forms a classification scheme for any visualisation system.

Designers of visualisation systems would likely benefit from applying this classification scheme as a tool of optimisation in the design process. Based on the relevant properties of an information space to be visualised, the first task would be to identify a visual representation which conveys a maximum number of properties, in a level of abstraction as low as possible: A visual model would be preferable, a visual metaphor would be welcome, a visual formalism would likely require reconsidering. Based on this master representation, supplementing visual representations could then be designed to convey aspects of the underlying information space not yet considered. Applying this method could result in visualisation systems which, while retaining the ease of use and the low learning requirements of model- and metaphor-based systems, do not hide semantics or oversimplify complex inter-relationships by expressing non-obvious properties of information spaces through more suitable, carefully designed formalisms.

7 - Acknowledgements

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References

- [1.] E. R. Tufte, *"The Visual Display of Quantitative Information"*, Graphic Press, Cheshire 2001
- [2.] T.Bemers-Lee, J.Hendler and O.Lassila, *"The Semantic Web"*, Scientific American, May 2001
- [3.] E.Rennison, *"Galaxy of News: An Approach to Visualizing and Understanding Expansive News Landscapes"*, ACM Symposium on User Interface Software and Technology, USA, 1994
- [4.] K.Andrews, J.Wolte, M.Pichler, *"Information Pyramids"*, IEEE Visualization, USA, 1997
- [5.] S.K.Card, J.D.Mackinlay and B.Shneiderman, *"Information Visualization: Using Vision to Think"*, Morgan-Kaufmann, San Francisco, USA, 1999
- [6.] B.Shneiderman and C.Plaisant, *"Designing the User Interface: Strategies for Effective Human-Computer Interactions"*, Addison-Wesley, Reading, USA, 2004
- [7.] R.Burkhard and M.Eppler, *"Knowledge Visualisation"*, in: T.Keller and S.O.Tergan, *"Knowledge and Information Visualisation"*, Springer, Germany, 2005
- [8.] J.J.Thomas and Kristin A. Cook, *"Illuminating the Path: The Research and Development Agenda for Visual Analytics"*, IEEE CS Press, USA, 2005
- [9.] M.Eibl, T.Mandl and M.Stempfhuber, *"Metaphors vs. Visual Formalisms in Visual Information Seeking"*, Panhellenic Conference on Human-Computer Interaction, Greece, 2001
- [10.] M.Granitzer, W.Kienreich et.al., *"Evaluating a System for Interactive Exploration of Large, Hierarchically Structured Document Repositories"*, 10th IEEE Symposium Information Visualization, USA, 2004
- [11.] W.Kienreich and M.Granitzer, *"Visualising Knowledge Webs for Encyclopedia Articles"*, 9th International Conference on Information Visualization, UK, 2005
- [12.] M.Granitzer, W.Kienreich et.al., *"WebRat: Supporting Agile Knowledge Retrieval through Dynamic, Incremental Clustering and Automatic Labelling of Web Search Result Sets"*, 1st IEEE Workshop on Knowledge Management for Distributed Agile Processes, Austria, 2003
- [13.] I.Dudek and J.Y.Blaise, *"From Artefact Representation to Information Visualisation: Genesis of Informative Modelling"*, 5th International Smart Graphics Symposium, Frauenwörth Cloister, Germany, 2005
- [14.] W.Kienreich and M.Granitzer, *"Geospatial Anchoring of Encyclopedia Articles"*, 10th International Conference on Information Visualization, London, UK, 2006
- [15.] W.Kienreich, *"Brockhaus Planetarium"*, Research Prototype, Information at www.know-center.at

Expériences au laboratoire ARIA.

Dans cette brève présentation nous essayerons d'illustrer de quelle manière les outils numériques peuvent faciliter la compréhension et la mise en relation subjective d'informations abstraites et disparates. Prenant appui sur un travail de recherche mené conjointement à l'équipe " les métiers de l'histoire " de l'école d'architecture de Grenoble, le sujet proposé essaie de construire le modèle simplifié d'un système de structuration et de représentation des connaissances apte à en faciliter la recherche, la description et la manipulation.

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1 - PRESENTATION GENERALE

Dans ce souci de “faciliter l'accès et la mémorisation “ des informations collectées nous avons bien entendu cherché dans un premier temps à recenser les travaux et recherches engagés sur cette voie, et ce dans des domaines connexes au domaine de l'architecture et prenant place plus précisément au sein de produits hypermédia développés par le laboratoire MAP lui-même ou ses partenaires proches. Ce programme de recherche se propose de contribuer à l'étude et à la mise en place d'un système simplifié de gestion de bases de données permettant d'enrichir l'ergonomie et de faciliter la navigation dans des environnements hypermédia:

- en simplifiant la description première des entités manipulées.
- en “différenciant“ le parcours en fonction du profil de l'utilisateur.
- en utilisant des outils et des langages “universels“, issus de la
- culture du web.

1.1. L'intégration aux travaux de recherche de l'aria

Le produit développé tire parti des outils réseau disponibles qui peuvent être en adéquation avec la problématique avancée. Dans l'appliquatif présenté en annexe nous avons principalement utilisé Javascript, VRML et HTML, implémentés suivant une logique “objet“ et permettant de visualiser en cours de le niveau de relation des entités hypermédia manipulées. Ce modèle, une fois finalisé, pourra utiliment enrichir les produits développés à l'avenir par le laboratoire MAP : il a été, à titre expérimental, “injecté“ dans le CD-ROM l'Urbatecture de Pienza duquel à été extrait le corpus ayant servi au développement et à l'expérimentation.

2 - LES OBJECTIFS DE LA CONTRIBUTION

2.1. La notion de profil utilisateur.

La réalisation de plusieurs produits dans le domaine du multimedia par les laboratoires partenaires de l'UMR MAP nous a conduits a remettre en question les pratiques “classiques” de scénarisation et de développement d'arborescences. Par “développement d'arborescences” il est précisément question de tout le travail permettant de relier les entités hypermédia en présence par des descripteurs logiques permettant d'en identifier filiations ou parentés et surtout d'en permettre une “représentation mentale” satisfaisante.

Il est certain que lors de la consultation d'un même produit hypermédia l'on soit tenté de naviguer ou de consulter le contenu suivant ce qu'il est convenu d'appeler “son propre regard”. Le recentrement perpétuel d'une “zone fovéale cognitive” autour d'entités hétérogènes suppose



que l'on puisse faire émerger les objets cognitifs en présence suivant une logique de circonstance, ce que Alain Rénier, professeur des écoles d'architecture présente comme une dynamique actancielle. Identifier l'utilisateur revient donc à pré-filtrer l'information présente afin d'en donner à voir qu'une partie susceptible d'intéresser de prime abord l'utilisateur présent. Dans cette optique, il est nécessaire d'être en mesure d'attacher à tout objet du corpus certes l'ensemble des informations qui le caractérisent mais aussi de pouvoir extraire de cette description les renseignements utiles aux questionnements formulés par un utilisateur quelconque. Le problème est donc d'être capable de trier cette information et de la restituer en fonction de questionnements particuliers, autrement dit de montrer que des aspects spécifiques extraits d'un ensemble exhaustif de connaissances pourra être filtré et donné à voir en fonction des besoins de chacun.

2.2 La notion de “système embarqué”.

Pour le CD-ROM l'Urbatecture de Pienza, l'équipe aria de l'UMR MAP a tenté de façon expérimentale de réunir les avantages d'un support numérique de type CD-ROM (grande capacité de stockage, prix de revient à l'unité...) aux techniques de diffusion liées aux réseaux (universalité, quantité de médias manipulés, remise à jour des données...) Le choix motivé des langages de description et de manipulation des données s'est logiquement orienté vers des systèmes susceptibles de traiter des corpus hétérogènes en présence de manière sûre, rapide et ouverte ne nécessitant pas de ressources logicielles ou matérielles complémentaires. Plutôt que de faire appel à des systèmes existants nous avons préféré développer, pour cette recherche, un moteur d'indexation embarqué permettant d'opérer sur la machine client le tri et l'affichage des objets recherchés.

Une attention particulière a été portée à la description d'une matrice d'indexation permettant de conserver une cohérence globale aux objets représentés, construite sur la base d'une description générale des objets du corpus, et qui est représentée ci-après.

2.3 Un système ouvert.

Les formats de médias ainsi que la nature des données qui sont aujourd'hui accessibles par le biais des réseaux, suivent une évolution constante : nous nous référons ici aussi bien au format de données, susceptible d'évoluer en fonction de simples mises à jour logicielles ou d'optimisations de portage, que à l'apparition de nouvelles ressources à proprement parler - le format propriétaire flash de Macromedia Director n'est intégré de façon native que dans les plus récentes versions des clients WWW existants sur le marché. Se pose alors d'emblée la question de pérenniser le “feuilletage” (browsing en anglais) de formats de données hétérogènes et qui

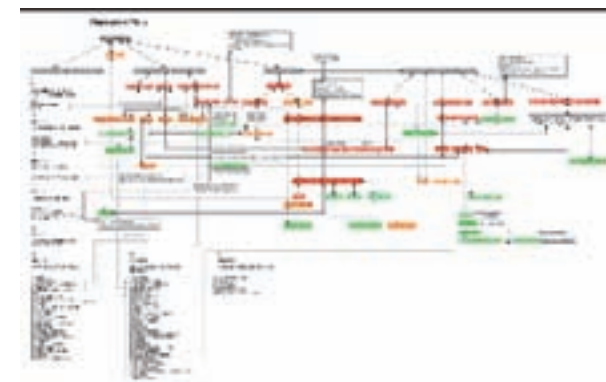


Fig. 1. le synopsis du CD-ROM

[

plus est, mutantes. La versatilité des logiciels clients W3 sont pour le moment garants d'une telle adaptabilité: autour d'un core logiciel relativement succinct - l'application elle-même - viennent s'articuler des traducteurs spécifiques (les plug-ins) aptes à prendre la relève lorsque les interpréteurs de données internes au browser sont incapables de reconnaître le format de fichier entrant, identifié par son suffixe. S'ajoute à cette difficulté liée à l'utilisation des outils numériques une caractéristique inhérente au domaine de la recherche qui, de manière très générale, construit son univers de connaissances la plupart du temps par "touches successives". Il s'agira enfin de résoudre un problème lié à la nature "hybride" du projet: savoir collecter et traiter des informations dont l'implémentation peut être délocalisée.

3 - LES PRINCIPES MIS EN OEUVRE

Nous avons vu que pour l'essentiel le projet proposé cherchait à développer un système permettant l'accès aux informations présentes dans une base de données "délocalisée" et ce dans un contexte coopératif s'appuyant sur des supports hypermédia largement diffusés de nos jours. L'approche retenue pour accéder aux informations consiste à permettre d'effectuer un tri dans un arbre de classes représentant le schéma de données disponibles tout en "donnant à voir" de façon immersive une maquette 3D qui servira de "réfèrent cognitif" à tout moment de la requête.

Les principes mis au service de cette contribution porteront essentiellement sur:

- La construction préalable d'une matrice d'indexation simple et ouverte permettant de conserver une cohérence globale aux objets représentés ou nouvellement intégrés.
- Des outils de structuration corollaires comme les modèles de croissance fonctionnant sur le principe de règles de substitution (graphes)
- Un moteur de recherche fondé sur le principe du filtrage par seuils.

3.1 Une logique "objet".

Le terme "objet" ne désigne ici que très modestement le principe retenu pour construire la matrice d'indexation qui servira à référencer et à structurer l'ensemble des médias qui constitueront la base de données: le système d'interrogation auquel nous ferons appel pourra être modélisé par la fonction suivante:

Information recherchée = F (utilisateur , section disponible , mot clé)

Les paramètres de cette fonction étant informés par:

utilisateur: nous avons brièvement décrit dans la section précédente l'intérêt représenté par l'identification préalable de l'utilisateur, ceci permettant d'accorder ou non des privilèges en consultation ou en écriture.

section disponible: l'ensemble des informations faisant partie d'un corpus en construction de façon permanente, la possibilité d'ouvrir ou de temporairement fermer l'accès à des sections "en ligne" en cours d'indexation nous semble primordiale.

mot clé: le point de départ de la recherche naviguée se fera par le choix d'un item disponible dans une liste d'objets référencés sous une section accessible - il donnera lui-même accès de façon filtrée à tous les objets connexes disponibles; le filtrage dont il est question ici est détaillé dans les deux sections suivantes.

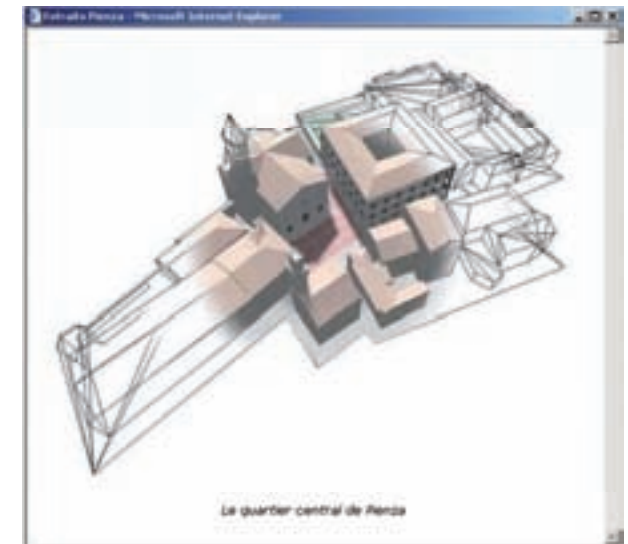
Le découpage spécifique des informations qui a été choisi pour structurer et représenter les médias dans le CD-ROM "L'Urbanisme de Pienza" fait apparaître en premier lieu les objets connexes au mot-clé affiché (ici La Place) ; il présente ensuite les médias disponibles en rapport avec la thématique (textes, animations, images...) L'implémentation de ce principe a été effectuée pour l'instant en indexant manuellement les médias existants en rapport avec l'objet affiché. Le sujet proposé tente d'automatiser et de simplifier l'indexation des médias disponibles.

3.2 L'apport d'outils logiques corollaires: développement d'un moteur de croissance "graphtal".

Parmi les systèmes d'indexation existants ou préalablement développés et utilisés par l'équipe MAP [CD-Recherche, Flash-Index...], nous avons cherché quels outils logiques pourraient servir de référent "analogue" au tri et à l'indexation des informations.

Les graphtals, qui permettent de simuler la croissance d'objets naturels, sont basés sur un alphabet de formes primitives, les germes, et sur un ensemble de règles de production chargées de faire évoluer l'objet dans le temps. Par exemple, l'étude de la croissance des plantes montre que leur développement obéit à des lois relativement simples qui vont attribuer des facteurs d'état ou de croissance à la position des bourgeons, à la dimension des rameaux, à la vitesse de pousse etc. Ces règles de croissance étant modélisées, on pourra reconstituer l'évolution de la plante.

La modélisation des plantes se fonde sur des bases botaniques qui discernent, dans la multitude de plantes existantes des règles simples permettant de construire une typologie de structure et d'évolution. Ces modèles font encore partie du monde de la recherche et ne sont pas encore tous implémentés dans les logiciels connus existants : le logiciel AMAP (Atelier pour la



haut mais présente cependant un certain nombre de difficultés qu'il s'agira d'identifier et de résoudre.

Pour décrire succinctement le principe mis en œuvre, à partir de la valeur chromatique d'un pixel sélectionné on cherche lesquels parmi les huit voisins en présence présentent des similitudes en deçà d'un seuil qu'il est possible de paramétrer. On procède ainsi par itérations successives jusqu'à épuisement des pixels voisins répondant aux critères sélectionnés. Ce principe, déjà exploité dans des logiciels commerciaux de traitement de l'image tels que Adobe Photoshop est utilisé de façon analogue au traitement et à l'affichage des objets du corpus. Il s'agit tout d'abord de définir les critères selon lesquels des objets ou mots-clés du corpus, peuvent être mis en relation. Dans le cas du CD ROM "l'Urbanité de Pienza" la mise en relation est bien entendu directement issue des observations ou des remarques que les historiens ou les philosophes de l'architecture avec qui nous avons collaboré ont pu formuler.

Si nous devons représenter maintenant les objets "vus" depuis le mot clé Roma (en gras dans le tableau) nous serions tentés de construire le graphe suivant, qui trace récursivement les objets reliés au mot-clé initial. Le moteur de développement de cette structure en arbre étant bien sûr dérivée du modèle graphal étudié précédemment. Sur cet exemple nous avons répété (et représenté) 5 itérations de recherche successives.

Nous avons ici fait apparaître en gris les occurrences redondantes, autrement dit les mots - clés à partir desquels une recherche d'objets associés à déjà été effectuée et pour lesquels il est inutile de poursuivre le "développement". Par la suite nous parlerons, pour préciser le fonctionnement du système, de filtrage incrémental. Ici il apparaît que la séquence [Roma / San Francisco / Grille Urbaine / Space Framework / Place / Machine à ombres], extraite de l'ensemble des informations de la base de données, pourrait presque constituer un iter discursif reconstitué regroupant l'ensemble des médias disponibles communs aux objets voisins. Le nombre d'itérations nécessaires pour avoir un panorama de voisins "exhaustif" constitue alors un problème tout à fait intéressant : on pourrait être par exemple tentés de se demander à partir de combien d'itérations la mise en relation d'objets pourtant reliés – comme pourraient l'être sur ce graphe Roma et la Machine à Ombres, distants de quatre seuils – participe à créer du sens ou à permettre de mieux cerner la globalité des informations. Il est probable que le couple [Rome/Horizon Urbain] ne fasse apparaître qu'un ensemble relativement limité (et intrinsèquement local) de données qui de part leur proximité sémantique ne classent que des médias dont le degré de redondance – autrement dit d'appartenance simultanée aux deux objets en présence - soit extrêmement fort. En revanche, le couple [Rome/Machine à Ombres] polarise dans cet exemple un trajet dont les ramifications multiples recoupent un grand nombre d'informations homologues du corpus et ce de façon transversale.

Fig. 2. les mots clés du corpus du cd rom [



Fig. 3. un développé cognitif contextuel [

4 - CONCLUSION

Nous avons vu que l'intérêt spécifique d'une architecture "objet" consistait à centraliser les informations en les formatant à l'aide d'une matrice d'indexation simple et ouverte. Dans cette maquette, les relations gérées restent modestes et l'expérimentation s'est faite sur un corpus comprenant un nombre restreint d'items. Par matrice d'indexation nous voulons désigner un masque de saisie capable de s'adapter à un grand nombre de configurations de données possibles : c'est le cas des objets de notre base de données, qui peuvent indexer un nombre important de médias qui plus est de formats différents.

L'implémentation pratique du projet à du tenir compte, nous l'avons vu, d'un certain nombre de contraintes imposées notamment par l'environnement logiciel et matériel qui servira de support à la consultation du corpus hypermédia. Nous allons à présent détailler certains des mécanismes régissant le fonctionnement du système projeté.

Une donnée majeure en terme d'utilisation de cette base de données consiste, nous l'avons vu, à créer "un niveau simplifié de représentation suffisant à exprimer un concept dont la description complète serait "perturbante". [Ameziane 1998] Mener à bien ce concept équivaldrait, dans ce projet, à identifier préalablement l'utilisateur afin de ne donner à voir qu'une partie des informations en présence. C'est pourquoi dans un premier temps il a été primordial d'implémenter simplement et de façon suffisamment robuste une fonction d'identification et d'attribution de privilèges d'accès. Celle - ci a été réalisée à l'aide d'une librairie JAVAscript, enregistrée sur serveur, et dont le suffixe *.js suffit pour en interdire l'accès en lecture et en écriture notamment à partir d'un client www ou ftp. Il n'est pas question ici de construire un système de filtrage d'accès "inviolable" mais simplement un moteur de traitement de données apte à garantir une navigabilité robuste et fiable.

The systematics of historic wooden floors with no plastered ceilings encountered in Poland

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Historic wooden floors with no plastered ceilings have been built in Poland from the 14th to mid 19th century. The presentation of those floors has been preceded with the description of their basic elements. The presented floors have been divided according to their decorative form into the following groups and subgroups:

I – Beamed floors

a – dense-beamed floors

b – beamed floors (normal)

c – beamed floor with cross-pieces

II – Beamed slide-in floors

a – dense-beamed slide-in floors

b – beamed slide-in floors

c – dense-beamed floors with middle ceiling

d – beamed floors with middle ceiling

III – Beam-and-coffer floors

a – deep

b – normal

c – shallow

IV – Coffered floors

a – bearing coffer floors

b – coffer floors with coffers suspended in between the beams

c – coffer floors with coffers suspended under the beams

V – Flat floors

a – floors with lower ceiling, with no upper one

b – floors with both lower and upper ceiling and with pugging

c – floors with both lower and upper ceiling and with sound boarding and pugging

d – deal floors

Key Words:
systematics, wooden floors, Poland

Categories:
J.5

1 - Introduction

The term “floor” denominates a horizontal cover of a given space from above. It divides a building into storeys, stiffens the walls, bears flooring with its working load. It also makes a thermal and acoustic barrier. Very often it received a decoration.

The extent of present paper is limited to the ceilings, in which wood does not only play a construction role, but also a decorative one, that means those, in which the wood is directly visible or makes a support for a painted decoration.

Thus the floors with plastered ceilings, or decorated with moulded plaster, appearing in Poland since the Baroque times, have been left out. Time limits of the present paper comprise the floors dating back to the period from the 14th to early 19th century.

The present elaboration of floor kinds together with their drawn axonometric presentation has been based on the authors previous publication entitled “*Stropy drewniane w Polsce – propozycja systematyki*” / “*Wooden floors in Poland – a proposition of systematics*”, Warszawa 1989 and makes a starting point for their multimedia visualisation.

The inseparable element of the systematics of floors is their terminology. Since the paper is to be presented in English, and the terminology refers to the floors occurring in Poland, the descriptions in drawings are bilingual.

2 – Elements of floors

The characteristics of the main elements of floors is as follows (Fig. 1.):

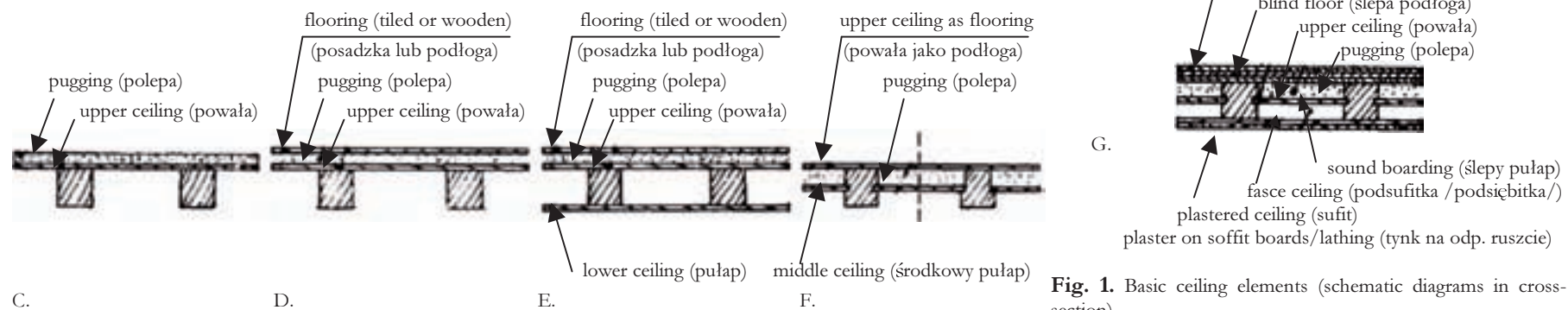


Fig. 1. Basic ceiling elements (schematic diagrams in cross-section).

Il. 1. Podstawowe elementy stropów (schematy w przekroju poprzecznym).

Beam is the basic bearing element, that in the majority of historic floors played also a decorative role, and in floors of the upmost storey made also a so called tie beam of the roof structure.

Upper ceiling is a layer of logs or planks placed directly over the beams (Fig. 1-A.). A floor consisting of those two elements exclusively (that is with no pugging) is sometimes called a **carcass floor/open floor**. It can usually be encountered in historic warehouses and granaries as well as under music-galleries in historic churches, where the upper ceiling served as a flooring.

The term **ceiling** generally means a layer of floor planks visible from beneath.

When those planks are nailed to the beams from below, they form the so called **lower ceiling** (Fig. 1-B.). Floors of such a structure are called **flat floors**. They are basically characteristic for church interiors, since they make a useful surface for painted decoration. In profane buildings they are encountered rarely (Fig. 1-E.).

There are also floors, in which the ceiling is placed in between the beams (Fig. 1-F.), in such a case it is called a **middle ceiling**. If that middle ceiling is covered from below with the plastered ceiling (or more rarely with a wooden lower ceiling) it is called a **sound boarding** (Fig. 1-G.).

In floors of the profane buildings the upper floor of the upmost storey is usually covered only with a **clay pugging** (Fig. 1-C.), while in the floors of lower storeys this pugging was laid with tiles (most often ceramic ones), or with wooden flooring. (Fig. 1-D and E.). In floors with the middle ceiling the pugging is usually put between this last one and the upper floor, being usually also the flooring (Fig. 1-F.). It also happens that the flooring, in form of a - for instance - parquet floor, is laid on the so called blind floor (Fig. 1 -G.).

In Baroque times floors with a ceiling appeared (Fig. 1-G.), where the plaster is laid on the lower surface of the floor on the **false ceiling/soffit boards**, also called the **lathing**, made of a batten grating or a layer of reed nailed to the floor boards.

3 – Systematics of floors

The systematics of wooden floors (with no plastered ceilings) has been based on their decorative form, taking into consideration also construction elements influencing the given formal solutions. According to the above rule among the wooden floors so far encountered in Poland one can distinguish the following groups:

- I. **Beamed floors** (Fig. 2, 3, 4.)
- II. **Beamed slide-in floors** (Fig. 5 and 6.)
- III. **Beam-and-coffer floors** (Fig.7.)
- IV. **Coffer floors** (Fig. 8.)

V. **Frame floors** (Fig. 9.)

VI. **Flat floors** (Fig. 10, 11, 12.)

4 – Beamed floors (Fig. 2.)

The term beamed floor is used to name the covers of rooms, in which the bearing elements – beams – are visible from below basically in their full height. They bear the upper ceiling with pugging and flooring (tiled or wooden). Due to the spacing of the bearing elements one can distinguish:

- dense-beamed floors
- beamed floors (normal).

In **dense-beamed floors** the spacing between the beams is from ca. 60 to ca. 70cm, and in normal beamed floors it is over 1.0 m.

Due to the way the upper ceiling is arranged one can distinguish:

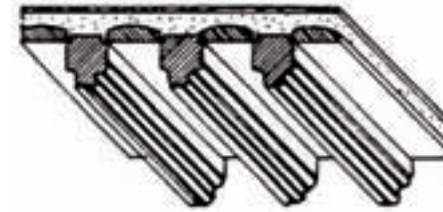
- beamed floors (normal)
- beamed floors with cross-pieces.

In **dense-beamed floors** the upper ceiling (of boards or logs) is usually placed along the beams, rarely cross-wise.

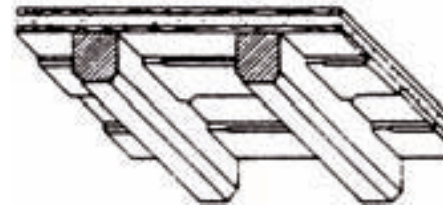
In **beamed floors (normal)** the upper ceiling (Fig.3.) is usually laid across the beams and consists of continuous boards (or logs), smooth or partly bevelled or moulded. Beamed floors with upper ceiling laid slantwise, in the so called herring-bone pattern, are exceptions (Fig. 3-C.).

In **beamed floors with cross-pieces** upper spaces between the beams are divided into rectangular (more rarely triangular) fields (Fig. 4.) with thick slats or little moulded beams. Most often the cross-pieces cover the joints between boards (or logs) of the upper ceiling.

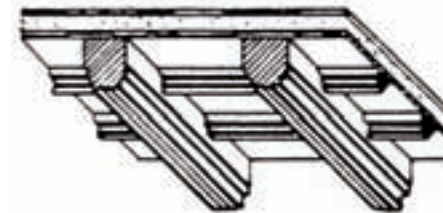
Beamed floors with cross-pieces are of the Gothic origin and should not be mistaken for beam-and-coffer ceilings, typical for the Renaissance period. Naming them pseudo-coffer floors or apparent coffer is a mistake.



A. Dense-beamed floor
(strop gęstobelkowy)



B. Beamed floor
(strop belkowy)



C. Beamed floor with cross-pieces
(strop belkowy z poprzeczkami)

Fig. 2. Beamed floors.

Il. 2. Stropy belkowe

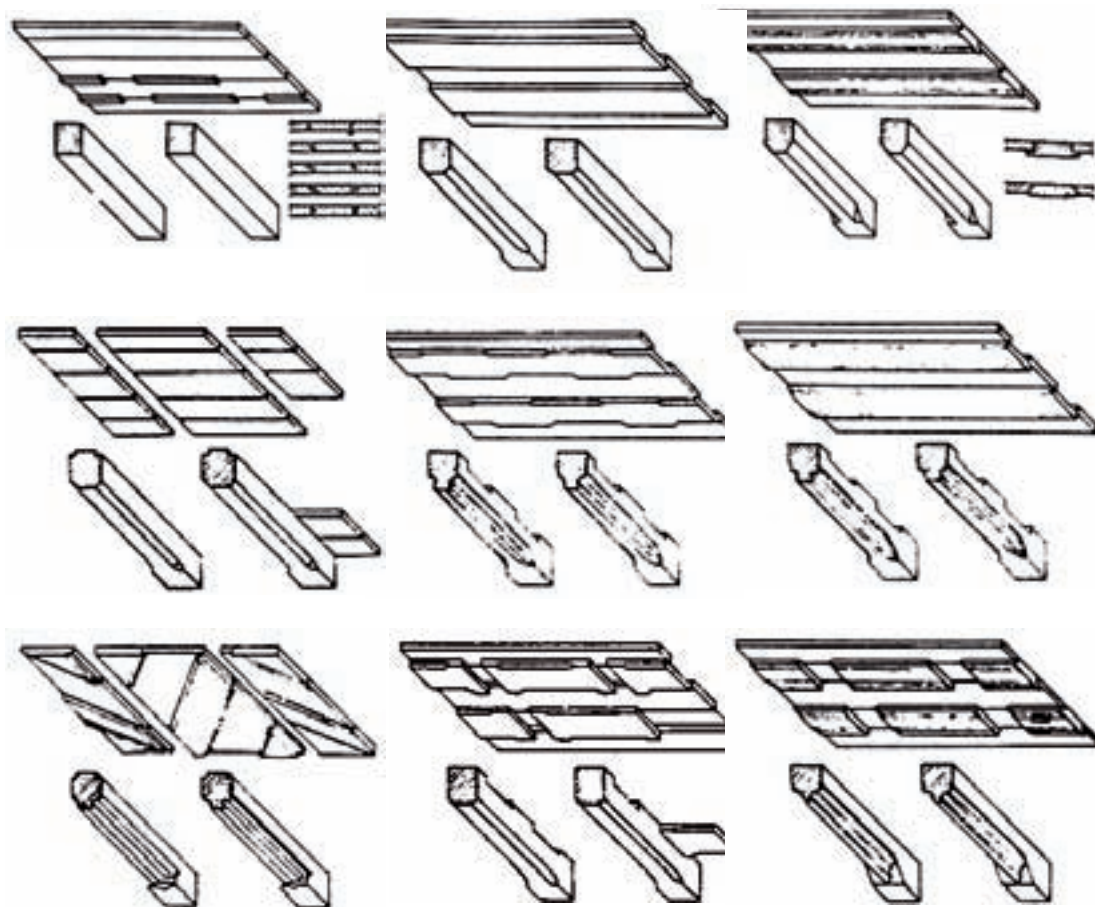
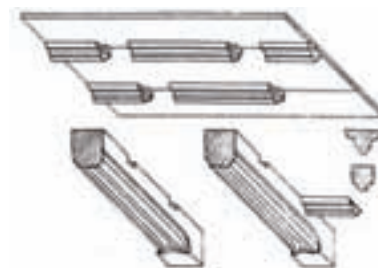
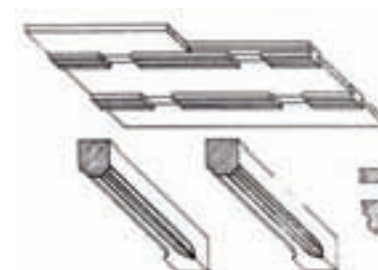


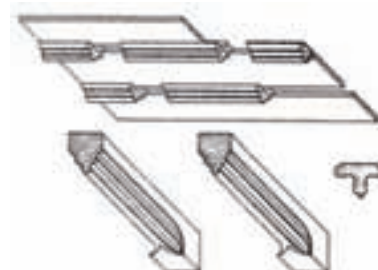
Fig. 3. Upper ceilings of beamed floors.
Il. 3. Powąły stropów belkowych.



A.



B.



C.

Fig. 4. Upper ceilings of beamed floors with cross pieces.
Il. 4. Powąły stropów belkowych z poprzeczkami.

5 – Beamed slide-in floors (Fig. 5.)

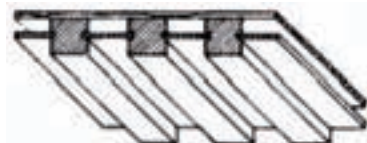
The term beamed slide-in floors is used to name such covers of rooms, in which the bearing elements – beams – (as seen from below) are only partly visible, since the middle ceilings with pugging are placed between them. The upper ceiling then most often serves also as a flooring.

The way the middle ceiling is set in the beams can be observed only after dismantling the upper elements of the floor:

- when it is slid in the grooves on the sides of beams the middle-ceiling is called a **slide**
- when it is rested in deep notches, cut in upper edges of the beams it is called just **the middle ceiling**.

Beamed slide-in floors, depending on the spacing between the bearing elements, would be named (just as beamed floors) **dense-beamed slide-in floors** or **beamed slide-in floors**.

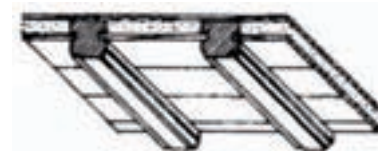
In dense-beamed slide-in floors middle ceilings are usually laid along the beams. In beamed slide-in floors the middle ceilings (slides), smooth or moulded, more rarely bevelled, are usually laid square with the beams (Fig. 6 A, B.), only in exceptional cases slantwise, in a herring-bone pattern (Fig. 6 C.).



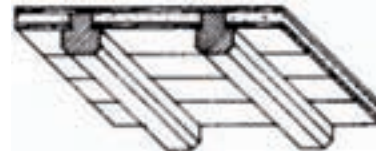
A. Dense-beamed slide-in floor
(strop gęstobelkowo-wsuwkowy)



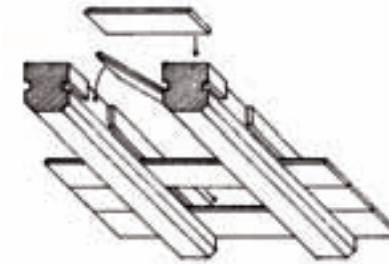
C. Dense-beamed floor with middle ceiling
(strop gęstobelkowy z środkowym pułapem)



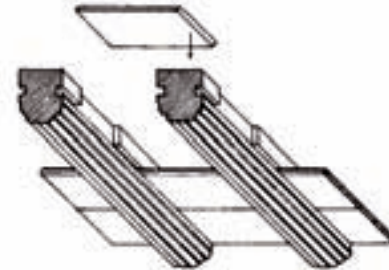
B. Beamed slide-in floor
(strop belkowo-wsuwkowy)



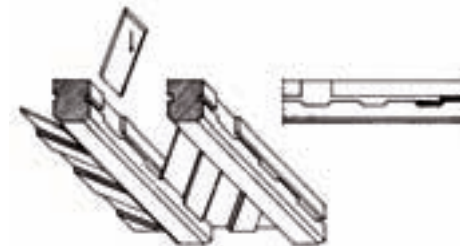
D. Beamed floor with middle ceiling
(strop belkowy z środkowym pułapem)



A. Inserted and shifted slides
(wsuwka wkładana i przesuwana)



B. Inserted and shifted slides
(wsuwka wkładana i przesuwana)



C. Herring-bone pattern slide inserted and shifted in a „groove” incised in the profile
(wsuwka w „jodełkę” wkładana i przesuwana w „rowek” docięty do profilu)

Fig. 5. Beamed slide-in floor
Il. 5. Stropy belkowo-wsuwkowe

Fig. 6. Ceilings of beamed slide-in floors (slides).
Il. 6. Pułapy stropów belkowo-wsuwkowych (wsuwki)

6 – Beam-and-coffer floors (Fig. 7)

The term beam-and-coffer floors is used to name such covers of rooms, in which between the moulded beams, in their upper parts (or even above them), rectangular recesses are formed of moulded slats running around the four sides of each of them, forming less or more deep coffers.

The view of such floor from beneath is dominated with the beams. They are not to be mistaken for beamed floors with cross-pieces, however surely those were in our territory the inspiration for them. Those floors, according to the depth of the coffers can be divided into:

- A. Deep beam-and-coffer floors
- B. Beam-and-coffer floors (normal)
- C. Shallow beam-and coffer floors

Deep beam-and-coffer floors are the most three-dimensional, since the coffers are developed above the beams or in their upper parts, when the beams are higher.

Beam-and-coffer floors (normal) have not so deep coffers developed in upper parts of beams of an average height.

Shallow beam-and-coffer floors have upper floors shaped with no cross-bars, only with moulded planks or slats composing rectangular, shallow fields resembling panels.

7 – Coffer floors (Fig. 8.)

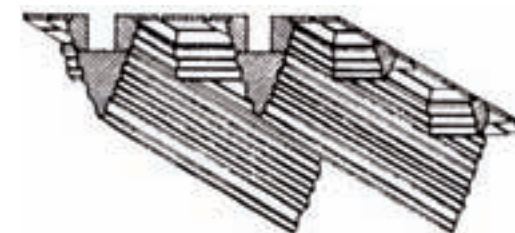
The term coffer floors is used to name such covers of rooms, in which the lower ceilings are shaped in a form of recessed fields, called coffers, the lower edges of which are on the same or similar level. The coffers can be shaped in square form only (or nearly square rectangles) or they can assume the shape of regularly distributed diverse geometrical forms (circles, hexagons and octagons, diamonds, stars, crosses etc.)

In classically designed floors of that type the coffers contain gilded rosettes on blue or violet background. They were to symbolise the sky.

One can distinguish: **bearing coffer floors** (Fig. 8 A.)

and **suspended coffer floors** (Fig. 8 B and C.)

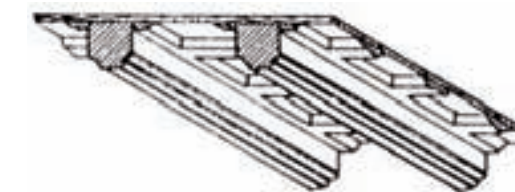
In bearing floors the beams intersect with decorative cross-bars of usually the same cross-section , often moulded. In suspended coffer floors the bearing beams are not visible, and the coffers play purely decorative role. They can be placed between the beams (Fig. 8 B.) or below them, attached to the false ceiling (Fig. 8 C.). This last solution allows for using the coffers of any desired shape.



A. Deep beam-and-coffer floor
(strop belkowo-kasetonowy głyboki)



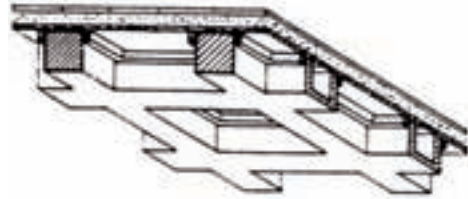
B. Beam-and-coffer floor
(strop belkowo-kasetonowy)



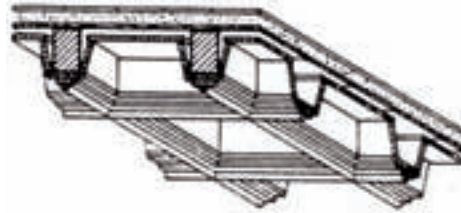
C. Shallow beam-and-coffer floor
(strop belkowo-kasetonowy płytki)

Fig. 7. Beam-and-coffer floors.

Il. 7. Stropy belkowo-kasetonowe



A.
/Bearing/ coffer floor
(Strop kasetonowy /konstrukcyjny/)



B.
/Suspended/ coffer floor (Stropy kasetonowe /podwieszane/)

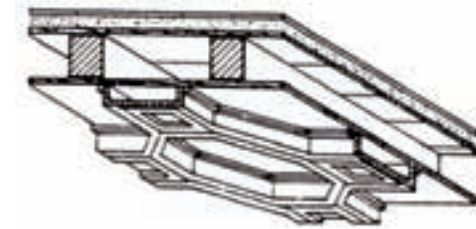


Fig. 8. Coffered floors.
Il. 8. Stropy kasetonowe

8 – Frame floors (Fig. 9.)

While coffer floors are the result of the influence of the Italian *Quattrocento*, the frame floors originate in the Venice *Cinquecento*.

The term **frame floors** is used to name such covers of rooms, that have suspended systems of connected frames attached to the construction. The frames surround fields of various shapes meant for painted decoration.

Frames and borders of those floors usually received also some carved decoration (painted and/or gilded).

9 – Flat floors (Fig. 10.)

The term **flat floors** is used to name such covers of rooms, in which the lower wooden boarding (that is the lower ceiling) is even, or only slightly differentiated. One can distinguish in this group:

9.1. Floors with lower ceiling:

- **floors with lower ceiling, without the upper one** (Fig. 10 A.)
- **floors with both lower and upper ceiling, and with pugging** (Fig. 10 B.)
- **floors with both lower and upper ceiling, and with sound boarding and pugging** (Fig. 10 C.).

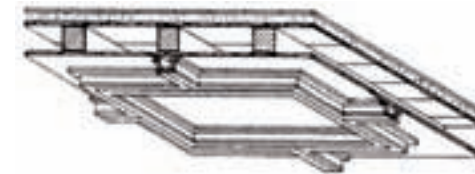
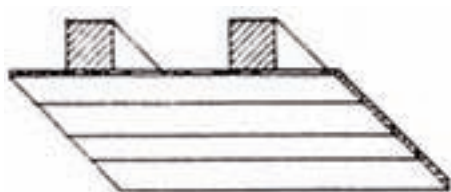


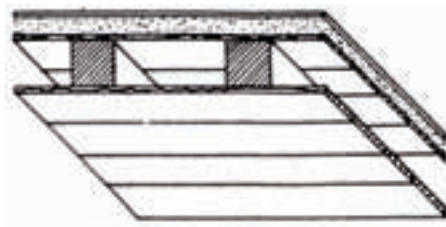
Fig. 9. Frame floor.
Il. 9. Strop ramowy.

The systematics of historic wooden floors with no plastered ceilings encountered in Poland

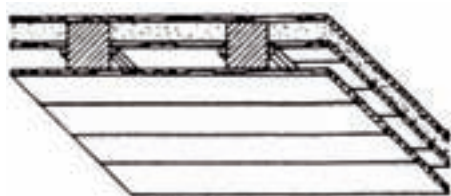
Floors with lower ceiling, without the upper one are characteristic for sacred interiors. They usually make the support for painted decoration, and their batten divisions assume various shapes (Fig. 11).



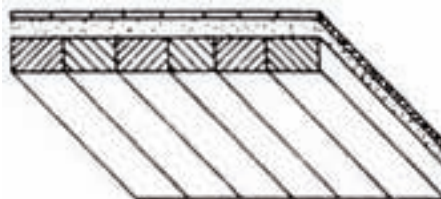
A. Floor with lower ceiling, without the upper one
(strop z dolnym pułapem bez powały)



B. Floor with both lower and upper ceilings
/pugging over the lower ceiling
(strop z dolnym pułapem i powałą
/polepa nad powałą)



C. Floor with both lower and upper
ceilings /sound boards with pugging
between the beams
(strop z dolnym pułapem i powałą
/ślepy pułap z polepą między belkami)



D. Deal floor
(strop dylowy)

Fig. 10. Flat floors.
Il. 10. Stropy płaskie

Plank ceilings
(pułapy deskowo)

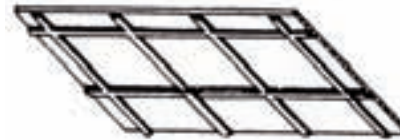
Plank and batten ceilings
(pułapy deskowo-listwowo)

Plank-batten-coffer ceilings
(pułapy
deskowo-listwowo-kasetonowe)

Fig. 11. Floors of flat ceilings.
Il. 11. Dolne pułapy stropów płaskich.



A. Butt-joint ceiling
(na styk)



F. Batten and coffer ceiling
(listwowo-kasetonowe)



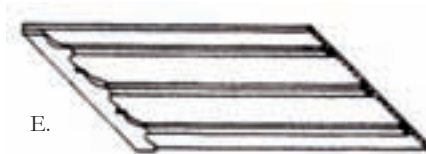
D.



B. /polish/ lap joint ceiling
(na zakładkę /na nakładkę polską)



G. Batten and frame ceiling
(listwowo-ramowe)



E.

The systematics of historic wooden floors with no plastered ceilings encountered in Poland

9.2. Deal floors (match board floors) (Fig. 12.)

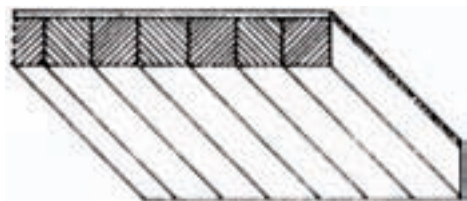
Deal (match board) floors are characterised with the bearing elements – mostly deals (match boards), more rarely beams, one directly next to other.

The deals are usually laid in such a way, that they resemble a timber wall lied down. To provide their collaboration the deals are usually joint with wooden dowels, distributed usually by three along the whole length of the bearing element.

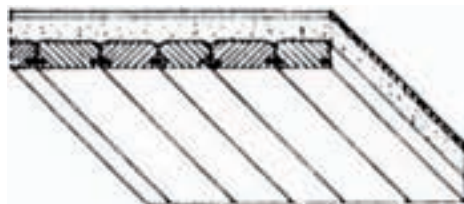
In some deal floors additional battens were used to prevent the pugging from pouring through the slits (Fig. 12 B.). The same effect has been also achieved by laying the deals in two levels, the lower ones being shaped in a form of a diverted letter “T” (Fig. 12 D.). The moulded deal floors were built according to the same principle. (Fig. 12 E.).

Deal floors with clay pugging and flooring of ceramic tiles have been fire-proof, and as such often used in arsenals and army warehouses.

SMOOTH (GŁADKIE)



A.

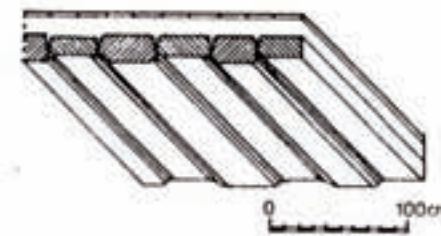


B.



D.

MOULDED (PROFILOWANE)



E.

Fig. 12. Deal floors.
Il. 12. Stropy dyłowe /brusowe/.

10 – Conclusion

In the analysis of historic architecture, as well as in its conservation issues (especially in the age of computers) a precise and explicit defining of the particular construction elements plays quite an important role. Among those are also the floors, the sistematization, proper onomatology and possibly short definitions of which were the aim of the present paper.

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References

- [1.] J. Frycz, *Stropy w kamienicach mieszczańskich w Polsce*, Zeszyty Naukowe Uniwersytetu Mikołaja Kopernika w Toruniu, Zabytkoznawstwo i Konserwatorstwo I, Toruń 1966, pp. 169-200
- [2.] O. Gruber, *Decke*, [in] Reallexikon zur Deutschen Kunstgeschichte, t. III, Stuttgart 1954, szp. 1127-1139
- [3.] W. Kalinowski et W. Krassowski, / A. Miłobędzki, *Z problematyki budownictwa drewnianego epoki odrodzenia*, Biuletyn Historii Sztuki, R XV. 1953, nr 3/4, pp. 34
- [4.] J. Lorenz, *Stropy drewniane w kamienicach Wrocławia i ich problematyka konserwatorska*, Toruń 1989, (maszynopis) praca magisterska, UMK w Toruniu, napisana pod kierunkiem J. Tajchmana
- [5.] Z. Mączyński, *Elementy i detale architektoniczne w rozwoju historycznym*, Warszawa 1956, pp. 331-351
- [6.] A. Miłobędzki, *Architektura Polska XVII wieku*, Warszawa 1980, pp. 223-224
- [7.] E. Różycka, *Uwagi o renesansowych stropach w kamienicach Wrocławia*, [in] Komunikaty na Ogólnopolską Konferencję Konserwatorską poświęconą sprawie badań nad kamienicami mieszczańskimi i problematyce ich adaptacji do współczesnych potrzeb. Toruń 1963, pp. 12-14
- [8.] W. Sobocki, *Zabytkowe stropy drewniane w jarosławskich domach mieszczańskich*, Rocznik Stowarzyszenia Miłośników Jarosławia, R. 1962, pp. 97
- [9.] A. Swarczewski, *Nowo odkryte drewniane stropy gotyckie w Krakowie*, Teka Komisji Urbanistyki i Architektury, T. XV, Kraków 1981, pp. 41-48
- [10.] B. Wolff – Łozińska, *Malowidła stropów polskich I poł. XVI w.*, Warszawa 1971
- [11.] S. Żaryn, *Trzynaście kamienic staromiejskich – strona Dekerta*, Warszawa 1972

Between Design and Survey: Interpretative Problems in the Study of Drawings for Digital Modelling

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The aim of this study is to highlight some of the main problems concerning the interpretation of architectural projects – in the form of plans, models or collected data from survey – through the analysis of some case studies, and in relation to their digital modelling. The matters concerning the reconstruction of an architectural form, in fact, always require the knowledge of a number of aspects, which cannot be limited to the technical one.

We consider here some of the very remarkable works by Palladio [6]: many of his architectures are true interpretative puzzles, since there is a sharp difference between his drawings and realizations. As it has been often pointed out by Gioseffi [2] and Puppi [3] Palladio's drawings must be considered as "conceptual models", project abstractions showing an intention more than an actual geometrical-projective correspondence.

Another aspect we consider here concerns the perception of form: in many cases we have drawings looking like photographs of models and models (like the ones by Eizemann and Kawamata) made by deforming their morphology in order to look like drawings.

Besides such broad issues I shall consider a specific problem, namely the study of vaults – in particular the cross-vaults – reconstructed from drawings and data acquired during survey's operations. Also the employment of advanced laser relief methods can be ineffectual if they are not combined with a precise knowledge of the 3D structure of the architectural element that is analyzed.

Digital Representation, Modelling, Geometric Analysis, Numeric Survey, Virtual Reconstruction, Unbuilt Projects

SD I.3.5 – SD I.6.5 – SD F.2.2 - ** A.1 - * I.4.5**

1 - Introduction

The words “drawing”, “model”, “modeling”, “construction” have become even more ambiguous since the introduction of digital technology. Even if the discipline of architecture requires a terminological codification, the ambiguity remains an essential component of it. However, in the field of architecture the ambiguity often derives from the fact that while a 3D digital model contains a great part of the information pertaining to architectural 2D contents, it is not always possible to reconstruct a 3D model starting from 2D data. Therefore the ambiguity is both theoretical and practical. How can we face the problem when we analyze data with the aim of a stereometric reconstruction of an architecture?

It is necessary to start a process of interpretation, which should aim not only to determine the scientific terminology to be adopted as the most appropriate one, but which should also above all diminish the “mass of ambiguity” contained in an operation of morphological description of a work of architecture. The inquiry into and the solution of some specific cases, by means of university studies and researches [1] [7] [8] allow us to define a strategy of intervention, and raise some new issues to be debated.

2 – “Drawing vs. moving”?

One of the first authors who raised the problem of the necessity of a specific terminology to adopt in the field of computer graphics was Ivan Sutherland, the author of ‘Sketchpad’, the first system of interactive design. In Sutherland’s doctoral thesis on ‘Sketchpad’ [9] at the Massachusetts Institute of Technology (MIT), we find a paragraph entitled “Drawing versus moving”, where he states that: “An idea that was difficult for the author to grasp was that there is no state of the system that can be called ‘drawing’. Conventionally, of course drawing is an active process which leaves a trail of carbon on the paper. With a computer sketch, however, any line segment is straight and can be relocated by moving one or both of its end points”. As we know the system by Sutherland was originally a 2D one, even if only after few months the 3D application was developed, and the term “model” was soon introduced. Although the digital and analogical models have several characteristics in common, the main difference concerns what Sutherland himself was pointing out. The digital model is in fact a dynamic, changing one, and unlike the traditional one, it can be deformed, sectioned.

A remarkable example of the employment of the geometrical deformation in the field of architectural representation has been realized by a university research at the IUAV of Venice, directed by Camillo Trevisan [4]. It concerned the deformation of complex models of the perspective that Francesco Borromini realized in the mid-XVI century at Palazzo Spada in Rome (Fig. 1a). The aim of the research was the comprehension of the rules of the perspective

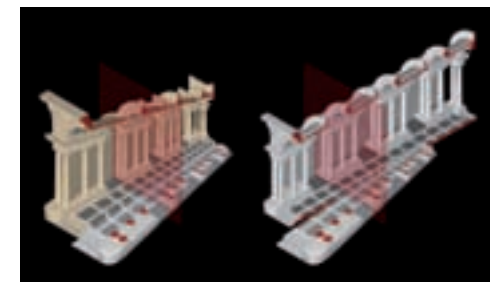


Fig. 1. The Perspective Gallery by F. Borromini in Rome: (a) – photographic image, (b) – deformed models [aut. A. Sdegno, 1999; aut. A. Sdegno, E. Garbin, 1999]

that Borromini applied in order to create the “solid perspective” of the colonnade (Fig. 1b). Even if we shall not consider now the whole complex study of projection, we can certainly highlight the algorithmic flexibility of the digital model of architecture.

3 - Palladian “drawings as models”

We all know that Andrea Palladio’s works are central to the history of architecture. But it should also become clear that they are equally important for the history of representation and for digital modelling. The analysis of some case studies will enable us to see some of the reasons why they are so important. We shall not enter the field of the history of architecture, but we shall deal with matters of representation and modeling. Before doing that, however, I shall introduce the problem, as some scholars have described it.

In his introduction to the catalogue of an important exhibition in London, titled “Andrea Palladio. The portico and the farmyard” [10], Howard Burns wrote: “Palladio is the most familiar of Italian architects. His name at once calls to mind great porticoed country houses and façades articulated with classical orders. But the very familiarity of Palladio is an obstacle to seeing him clearly”. As a matter of fact, if we observe any of his works, from the drawings contained in his treatise to the realized ones, we think that they are easily comprehensible and that all is ruled by the principles of symmetry and proportion, as a lexical application of the rules given by Vitruvius’s treatise 15 centuries before. Actually, the complexity of Palladian morphology emerges from a careful analysis, and even more so if we proceed to a redrawing of his whole work, both on the basis of graphic elaborations from the “Four Books”, and from the survey of the realized works which only partly correspond to his sketches.

Moreover, dealing with Palladio’s architecture it is necessary to put into direct relation the terms “drawing” and “model”, as some scholars have already done.

In particular, Decio Gioseffi as faced the topic of “drawing-model” in Palladio through a series of articles published on the *Bollettino del Centro Internazionale di Studi di Architettura Andrea Palladio in Vicenza*. Among them we should remember in particular the one [2] that deals with the origin of the term “model” (deriving from *modus*, meaning “measure”, and *modulus*, meaning “unit of measurement”) and arguing that it is necessary to consider the drawings by Palladio as abstract theoretical models, that is project experiments in progress. Gioseffi’s essay was published some years after an important exhibition in Vicenza, showing the construction of some wood models, such as that of ‘Palazzo Chiericati’ (Fig. 2b), starting from the drawings published in the “Four Books” (Fig. 2a). In the catalogue [11] published in that occasion the photographs of those models were not inserted; they appeared few years later, in a volume edited by Renato Cevese [12]. Few years later Lionello Puppi [3] thought it very difficult to be

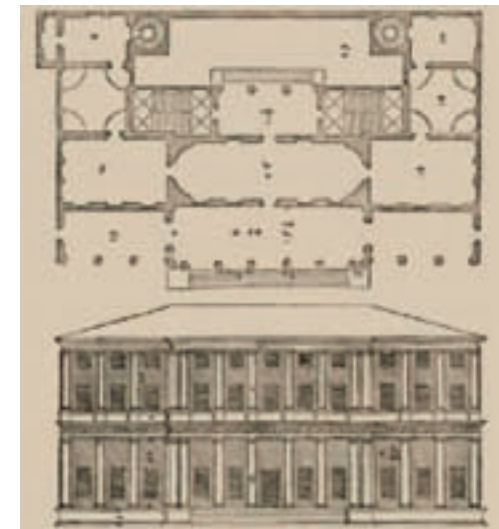


Fig. 2. ‘Palazzo Chiericati’ in Vicenza by A. Palladio: (a) – drawing, (b) – wood model [A. Palladio, *I Quattro Libri dell’Architettura*, Domenico de’ Franceschi, Venezia, 1570, II, p. 6; *Centro Internazionale di Studi di Architettura Andrea Palladio, Vicenza*]

able to reconstruct the models starting from Palladio's drawings, exactly because a high degree of interpretation was required, which often risked of giving a wrong description of the original idea.

In the field of the logical-morphological analysis of some of Palladio's works we will remember the studies of William Michell [13] above all, which face the problem from the semantic point of view and develop some previous researches [5] [14].

3.1. Between idea and construction: Villa Capra

Now we have to analyze some works by Palladio to clarify the aspects listed over. One of them is certainly Villa Capra, said "La Rotonda" (Fig. 3a). In this building the four pronaos were created and they present a building of great symbolic value. In fact, there is no main view, but we have a structure that faces all four cardinal axes equally. Another Palladian invention was that of the use of elements of sacred and public architectures, within private villas, like the upper triangular tympanum that gives the structure an unusual magnificence for a private house. A question arises from this architecture: was it created as Palladio wanted, or is it only a partial outcome of his intended plans? We ask ourselves this question when we compare a photographic image with the drawing that appears in his treatise of architecture [6]. The four pronaos are present, while the covering is quite different: in the published version we have a dome (another element taken from sacred art) that emerges from the building, while in the constructed version the dome is built into the stonework, so much so that it does not look like a hemisphere at all from the outside. The spherical form – quite extravagant for a private home – was hypothesized by Palladio. But this dome is an *unbuilt* element.

With digital instruments we can reconstruct the dome and carry out an overlapping of the two solutions (Fig. 3b) (see note 1.). We can hypothesize that, if Palladio had had our digital elaboration techniques available to him, he would have published this image in his treatise, as it shows the intention and realization in one sole figuration. In this case also, the comparison between the two ideas is possible and it allows for verification of the difference between them through two physical models. Besides this, we have to remind that the treatise is dated 1570 and was realized after the completion of the "Rotonda", even though using another project. This encourages us to consider his treatise as a work of idealization of projects, presentations of solutions and ideas, a repertoire of possible developments and conceptions (see note 2.).

Note 1. The reconstruction was done during my didactic activity at IUAV University of Venice in 2002.

Note 2. One must also remember that Palladio's treatise [6] is the first book of architecture that contains designs by the author himself.

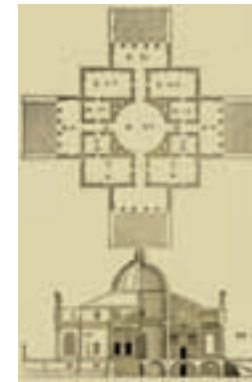


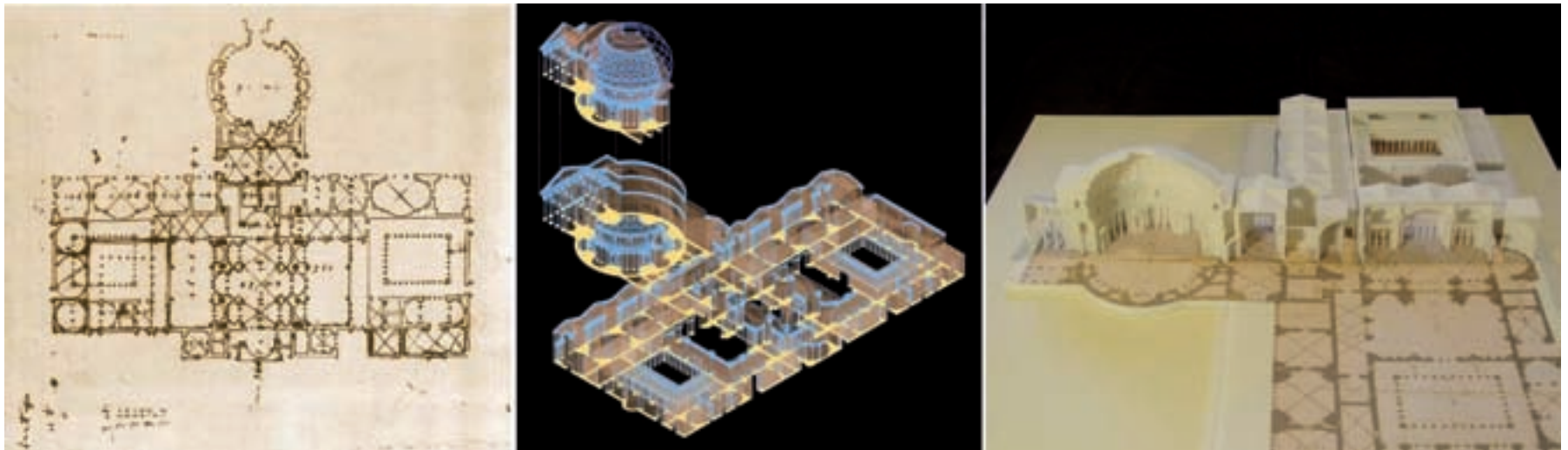
Fig. 3. Villa Capra, said "La Rotonda" by A. Palladio: (a) – drawing, (b) – digital photomontage, [A. Palladio, *I Quattro Libri dell'Architettura*, Dominico de' Franceschi, Venezia, 1570, II, p. 19; aut. student D. De Santis, 2002]

3.2. The reconstruction of the *Terme di Agrippa*

Another interesting architecture is the *Terme di Agrippa* in Rome, as a unique case in which the author would design the “Antico”. This case was recently studied at IUAV University of Venice (see note 3.). The *Terme di Agrippa* are a singular example of innovative planning executed in the Roman period. It was a building where Romans met not only to have thermal baths at different temperatures, but also to do sports, to talk to friends, to discuss business and to feast. The *Terme di Agrippa* are the first thermal baths of antiquity and sprung from the center of Rome. But, in 1540, when Palladio was in Rome they were in a state of complete destruction. Only one building was left, the Pantheon, which is, even today, one of the most important ancient buildings in Rome. It served as an entrance hall. Palladio then began to make some hypothetical plans. We can imagine how this building, which no longer exists, could have been like. There are several beautiful sketches by Palladio (Fig. 4a) in the RIBA (see note 4.) archive in London that hypothesize some design solutions, first published in Zorzi [15].

Note 3. The reconstruction was made by Chiara Stefani during her thesis at IUAV University of Venice, and was partially published in: C. Stefani, *Les Thermes d'Agrippa à Rome*, in Sdegno [8], pp. 47-61.

Note 4. Royal Institute of British Architect.



This can be seen relatively clearly in some plans, in which, within the symmetrical framework, we find two different solutions: the square courtyard on one side and the rectangular one on the

Fig. 4. *Terme di Agrippa* by A. Palladio: (a) – drawing, (b) – digital reconstruction, (c) – physical nylon model [RIBA, London, Vol. VII, fol. 1; aut. C. Stefani, 2004; aut. Protoservice, 2005]

other side. It is therefore an operation of invention, a design hypothesis of a structure that did not exist.

Therefore, we have to ask ourselves: why did Palladio dedicate his time in planning a work that he would never execute? Owing to the characteristics of the project – the big size and the specific function – we can hardly imagine that it would be ever realized. So then why did Palladio re-plan it? Moreover, the care with which he draws it is amazing, a detail of admirable graphics. Thanks to the care taken by the author, it was possible to analyze the plan. It was possible to make all the singular elements of the work coincide in such a way as to transform these Palladian designs into a digital model (Fig. 4b), one model that synthesizes Palladio's operations, even though this was done with very traditional methods. Those who use Computer Aided Design techniques know well that when one enters hand-drawn plans in the computer's memory, many of the details are likely to be lost. It is often necessary to approximate measurements because CAD drawing is much more precise than pencil drawing, but in this case the correspondence is perfect. There is great accuracy in the tracing of the lines, as if it were a drawing that was destined for the construction site, to be used for the creation of the work. It was so precise that it was possible to reconstruct the physical model, using rapid prototyping techniques (Fig. 4c).

3.3. Re-designing an Acropolic Temple

During the same period that Palladio designs the *Terme di Agrippa* he is also interested in another structure. The drawings are what are left of this structure. They are kept at the RIBA archive (Fig. 5), and they were studied at IUAV, as the preceding case (see note 5.). Historians are not sure of the location of this structure. It could also be a pure planning exercise, without context. Either it may deal with the Temple of Ercole Vincitore in Tivoli, or it may be the Temple of the Fortuna Primigenia in Preneste. Both of them are small cities near Rome. We are interested in analyzing it, because it is an *unbuilt project*, not realized. We should say that it is very interesting, because there are two different versions with different types of drawings.

It is known that there is an area in which it is possible to recognize the ruins of the Tempio di Ercole Vincitore, and another one that shows the architectural complex of Tempio della Fortuna Primigenia in Preneste. All the palladian drawings have been analyzed and transformed in diagrams so that one can clearly see how many elements were used by Palladio to try to design this acropolic structure.

There are two kinds of drawings: in one case we have geometrical drawings with a very clean, clear mark, “in pulito” of two projections, the frontal view and the side view, while the plan that could immediately clarify the three-dimensional morphology of the project is missing; in the

Note 5. The reconstruction was made by Viviana Magnarin during her thesis at IUAV University of Venice, and was partially published in: V. Magnarin, *Un temple acropolique*, in Sdegno [8], pp. 63-73.

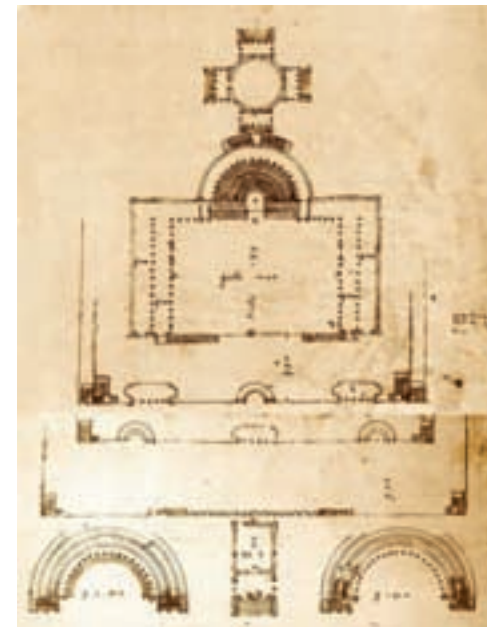


Fig. 5. Drawing for an Acropolic Temple by A. Palladio [RIBA, London, Vol. IX, Fol. 7]

other case, there are drawings in the forms of sketches of a plan and of a frontal view. They are difficult to decipher because they are a slightly blurred in the outline, even though very clear in the spatial configuration of the architectural structure.

It is very probable that it is not a drawing of an existing structure, but that it is an ideal plan, a hypothesis that was not meant to be realized. Maybe, as we would say today, we can consider it as an “academic” exercise, which only wants to experiment a montage of architectonic elements that can lead to a possible solution using the graphics technique. We must suppose that he had considered it an integral part of his curriculum necessary for the formation of an architect, the equivalent to a university thesis to obtain his degree and to be able to have access to the profession.

If we study these drawings, we will see that in the first case the structure ends at the summit of a small circular temple similar to the Temple of Vesta, proceeding down towards the lower part with a hemicycle, a portico-like structure, a large step system, to the central Temple with two other hemicycles on the sides and a portico structure below that defines three courtyards.

In the second case, however, there is a strange small temple with four pronaos at the summit, while all the other elements are located in similar positions – the upper hemicycles, the lower hemicycles, the temple, ect. – but they vary in dimension and morphology with respect to the preceding solution.

Some important characteristics can be identified in the two projects: in the first case we were able to reconstruct the geometry by recreating the plan that, as was mentioned, was missing. This was done by intersection. The perfect correspondence between the two existing vertical sections confirmed the hypothesis that Palladio surely had a plan as a first drawing and that, later, that drawing had been lost. In fact, we know that the Vicentine architect considered the plan of an architectural structure as the generator of the design, the instrument that one begins with, to proceed to successive architectural planning and developing. It is therefore an important result that has not been considered until this point. So we have all the main elements for the representation in order to construct the 3D model of the each part of the structure: the Tempio di Vesta, the hemicycles, the theatre, the main temple, the portico, and it is possible to render the whole structure with simulation software (Fig. 6a).

We can apply the same procedure to the second temple, from plan and elevation to obtain the third projection, the section. As in the preceding case, now we can create the 3D model of the structure. We can see that some elements change their morphology: the hemicycle is the same, also the temple, the theatre, some stairs, but on the upper level we have a structure with four pronaos.

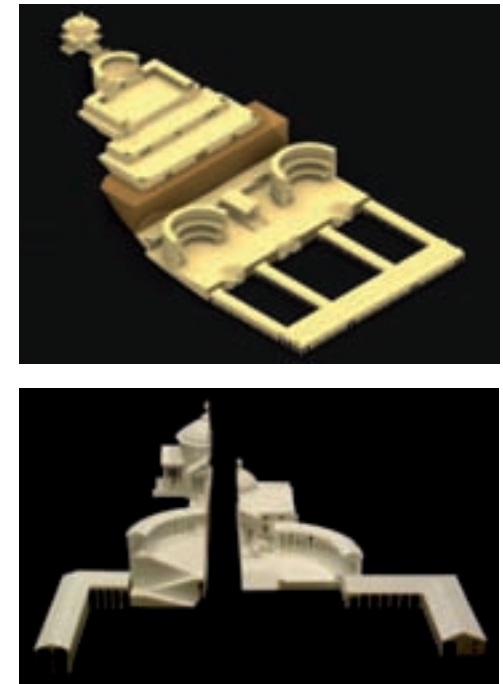


Fig. 6. Design for an Acropolis Temple by A. Palladio : (a) – digital reconstruction, (b) – physical nylon model, [aut. V. Magnarin, 2004; aut. Protoservice, 2005]

So, the second case, clarifies several work methods that Palladio used in architectural planning. In fact, some solutions were surely employed as base material for the executive planning of his other works, the ones that were actually realized. There is a figurative resemblance between the second version of the plan of the acropolic temple and the design for Villa Capra or Villa Trissino in Meledo, both of them published in Palladio (1570), though there are differences between drawings and buildings (in the first house the dome was not realized, and in the second one only a terminal fragment of the barchessa wing was realized).

The structure is the same, as we can transform the two projects – one into the other – with a few simple vertical and horizontal operations. The model is divided into two, the hemicycle change position, from up to down, and the main temple is inserted inside the two wings (Fig. 6b).

4 – The Representation Hinge: Touching and Seeing

Besides the problems concerning the morphology of an architecture, when one deals with representation, it is necessary also to inquire into the problems of modelling and visualization. If, as already stated, in some cases the graphic figuration gives the illusion to the observer to be in front of a real scene (as an example, see the panoramic drawing of the ‘Three million inhabitant Town’ by Le Corbusier) (Fig. 7), in other cases the model provides a representation of the drawing, solving some projective problems.

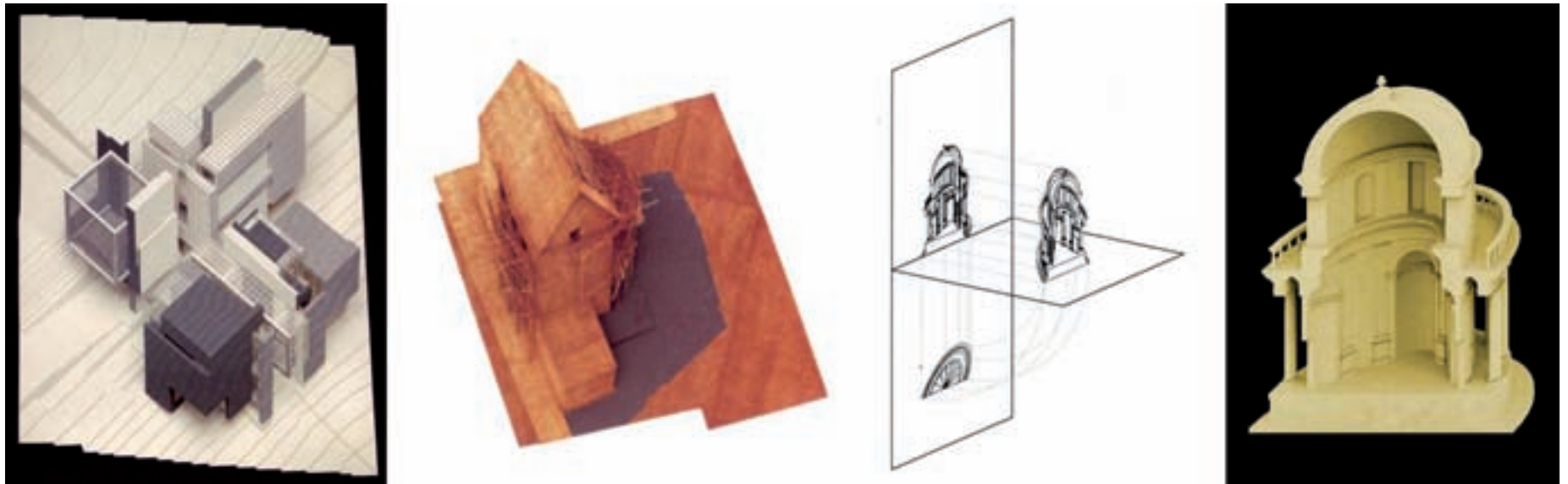


Fig. 7. The panoramic representation of the ‘Three Million Inhabitant Town’ by Le Corbusier [*Fondation Le Corbusier*]

The most evident one concerns the kind of projection: the human, “photographic” eye observes in fact a scene with a conic projection (from a proper point of view), while the “graphic eye”, has greater liberty since it can employ orthogonal projections, axonometries and perspectives. In

particular we shall try to analyze a kind of axonometry – the oblique one – which is very different from a perspective representation. In fact, if an orthogonal projection is figuratively close to a perspective, even if it is completely different from a projective point of view, an oblique axonometry is sharply different from a perspective.

If, for example, we observe Peter Eisenman project for the 'House X' (Fig. 8a) or the one by Tadashi Kawamata for 'The House of Squatters' (Fig. 8b) we notice that the two physical models have something in common. In both cases they are deformed along an axis, so that they seem to be squeezed upon themselves. But if we observe them – even photographically – from a privileged stand-point, we can see what was the sense of such an operation.



The most frequent cases of an oblique axonometry, in fact, enable us to obtain either the real plan or the real elevation, which cannot be obtained by any photographic camera.

In order to verify the possibility of using this procedure – from photograph to drawing – we have constructed a solid digital model of an architecture, enabling us to verify the exactness of projective properties as well as the efficacy of the working method. We decided to analyse the 'Tempietto' of St. Peter in Montorio by Donato Bramante, built in Rome in XVI century, whose

Fig. 8. Deformed architectural models: (a) – 'House X' by P. Eisenman, (b) – 'The House of Squatters' by T. Kawamata, (c) - diagram of the 'Tempietto' of St. Peter in Montorio, - (d) 'Tempietto' of St. Peter in Montorio [*A+U*, 1980, n. 112, *frontespice*; London, *Annelly Juda Fine Art*; aut. A. Sdegno, 2004; aut. A. Sdegno, 2004]

specific elements – such as the doric order, the pilaster strip, the pediment – require a particular ability in the creation of the model, and in the descriptive projection of them, which is very difficult to realize with traditional techniques on paper.

When the model was realized, utilizing boolean interactive graphic tools, we began to deform it (Fig. 8c), visualizing the result in orthogonal view (Fig. 8d), to control directly the correctness of the work.

At the end of the operation, it was necessary to control the analytic values generated by the method, in order to verify the results and compare the geometric forms obtained. Following the homology criterion, it was possible to associate the oblique projections of the “Tempietto” with the orthogonal projection of the deformed model.

The initial stereometric configuration was perfectly superimposed to the one obtained after the manipulation, so that the hypothesis of an affinity between deformation and projection was proved.

Deforming a model could be a useful way to understand the geometry of an architecture, and the laws that define the mechanism of projection.

5 – Between Design and Survey: some Geometric Reflections on the Construction of Vaults

The last aspect we shall consider is a specific case of architectural geometry, that is the vaults system. We know that there are many kinds of architectural vaults, and in order to have a simplified but representative cases of them it is useful to refer to Andrea Palladio’s classification in his treatise. In one of his drawings he shows us the way in which these vaults are determined (Fig. 9a).

Now if we consider the solution he adopted for the Convento della Carità, we shall find something odd. The rigour with which Palladio describes the vault systems – we should remember that Palladio devotes a chapter of his treatise to the “abuses” – clashes with the way he employs them in the courtyard. We would expect, in fact, to see a non vaulted system for the peristilium, since we have the trabeation in the façade which recalls the elementary structural system, and we have a simple a barrel vault. If we consider the solution adopted in other known porticoes, as for example the portico of the IUAV at the Tolentini (Fig. 9b), we might find ourselves in front of a series of a cross vaults, while Palladio employs this “strange” solution.

There is another place in the Convent where he uses the cross vault, and it is exactly in the tablinum, where there is a combination of a cross and lunette vaults (Fig. 9c). There is also a



Fig. 9. Some examples of vaults : (a) – palladian vaults, (b) – points’ cloud of the cross vault of the Tolentini (c) – geometric analysis of the cross vault of the tablinum in the *Convento della Carità*, [A. Palladio, “I Quattro Libri dell’Architettura”, Domenico De’ Franceschi, Venezia 1570, I, p. 54; aut. A. Sdegno and P. Vernier, 2006; aut. A. Sdegno, 2003]

difference in the heights, showing how Palladio meant to express the leading idea of the treatise: a combination of an ancient element (the cross vault) with a modern one (the lunette vault), constituting a sophisticated and very personal solution.

It would be interesting to make a 3D scanning in order to understand if there are slight constructive differences unveiling some further aspect of the complex history of the Convent.

This has happened to the cloister of the Incurabili in Venice (Fig. 10a), where after a very accurate scanning (Fig. 10b) it became evident that the real configurative geometry of the cross vaults of the path was slightly different from the known one (Fig. 10c).

The realization often brings with it a modification of the morphology of the original drawing.

6 - Conclusion

These examples demonstrate the need of expanding this research into the relationship between drawings and digital models, including more case studies and integrating the knowledge of historic-documentary and geometric-configurative to the drawing and survey activities, in order to enlarge the study to other fields and above all to verify the starting data.

The themes concerning the modeling require the overcoming of the classical identification of the operation of digital form construction with the algorithmic procedure. We must combine this codified procedure with a knowledge of the methods of plan and space geometry which have determined the basic rules for the production of the algorithm.

Therefore the study of the theoretical apparatus concerning matter of morphology appears to be an essential subject to pursue. The issue is to establish the modes to make the web governing the relations among the different disciplinary units both compatible and comprehensible.

References

Proceeding Papers:

- [1.] A. Sdegno, "From Architectural Intent to Physical Model: Representing the Chioostro della Carità with new technologies", [in] Proceedings CAAD Futures 2005, Dordrecht 2005, pp. 83-92

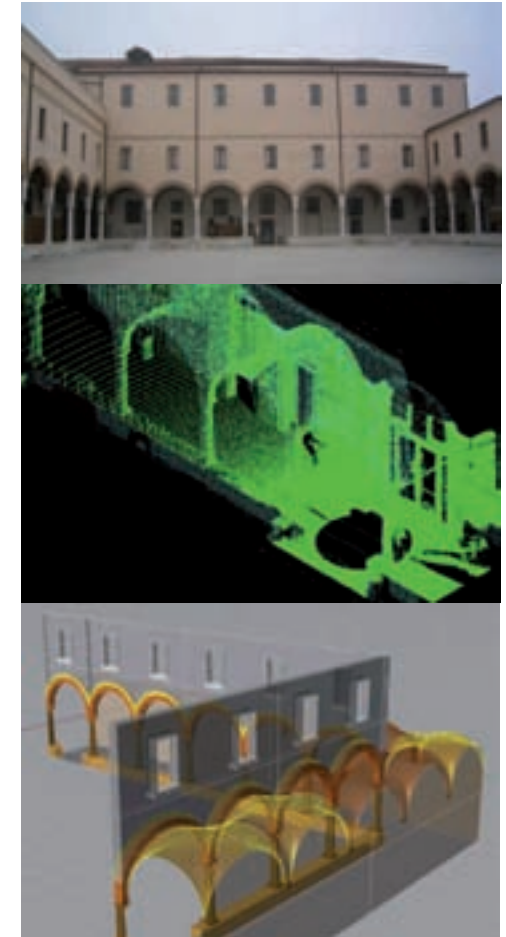


Fig. 10. The 'Incurabili' Cloister in Venice: (a) – photographic image, (b) – points' cloud, (c)- digital reconstruction [aut. A. Sdegno, 2006; aut. A. Sdegno and P. Vernier, 2006; aut. Student S. Terrana, 2006]

Journal Papers:

- [2.] D. Gioseffi, “I disegni dei ‘Quattro Libri’ come modelli; modellistica architettonica e teoria dei modelli”, *Bollettino CIS.A*, 1980, vol. XXII, part I, pp. 47-64
- [3.] L. Puppi, “Modelli di Palladio, modelli palladiani”, *Rassegna*, 1987, vol. 32, pp. 20-28
- [4.] C. Trevisan, “The Borromini Gallery in Palazzo Spada, Rome”, *Quaderni LAR*, 1999, vol. 4, pp. 17-30
- [5.] G. Stiny et W.J. Mitchell, “The Palladian Grammar”, *Environment and Planning B*, 1978, vol. 5, n. 1, pp. 5-18

Books:

- [6.] A. Palladio, “*I Quattro Libri dell’Architettura*”, Domenico De’ Franceschi, Venezia 1570
- [7.] A. Sdegno, “*Geometrie romane a Venezia. Il disegno del Convento Palladiano della Carità*”, Cafoscarina, Venezia 2005
- [8.] A. Sdegno, “*Digital Palladio*”, Cafoscarina, Venezia 2005
- [9.] I.E. Sutherland, “*Sketchpad. A Man-Machine Graphical Communication System*”, Phd Thesis, MIT, Boston, Mass. 1963
- [10.] H. Burns (ed.), “*Andrea Palladio 1508-1580. The portico and the farmyard*”, The Arts Council of Great Britain, London 1975
- [11.] AAVV, “*Palladio. Catalogo della Mostra*”, Electa, Milano 1973
- [12.] R. Cevese (ed.), “*I Modelli della Mostra del Palladio*”, Electa, Milano 1976
- [13.] W.J. Mitchell, “*The Logic of Architecture. Design, computation, and cognition*”, The MIT Press, Cambridge, Mass. 1990
- [14.] W.J. Mitchell, R.S. Liggett et T. Kvan, “*The Art of Computer Graphics Programming*”, Van Nostrand Reinhold Company, New York 1987
- [15.] G.G. Zorzi, “*I disegni delle antichità di Andrea Palladio*”, Neri Pozza Editore, Venezia 1958

The MADS Data Model

Concepts to understand the structure of your spatial and temporal data

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Successful information management relies on the ability to design accurate representations of the real world of interest, in spite of the diversity of perceptions from the applications sharing the same database. Current database management systems do not provide representation schemes that support adequate description of spatial and temporal features, and preserve the diversity of perceptions from the many users of a database while maintaining their consistency. This paper develops a data modelling paradigm where these facilities are fully supported within a user-oriented, conceptual modelling approach.

Keywords

Conceptual modeling, Database, Spatio-temporal data, Geographical Databases, GIS, Information Management

Categories

H1, H2, H2.1

1 - Introduction

The benefits of using a conceptual modeling approach to support database design are well known. Such an approach is commonly used for traditional databases, where the most used data models are the ER (entity-relationship) model [1] or UML (Unified Modeling Language) [2]. It is not so commonly used in geographical data management, where for a long time commercial systems have forced database designers to use logical data structures heavily influenced by internal implementation concerns.

A data model qualifies as conceptual if it enables a direct mapping between the perceived real world and its representation with the concepts of the model. In particular, a conceptual model does not have implementation-related concerns. While being conceptual, data models may have more or less expressive power, depending on the number of concepts and constructs they support. There is no obvious answer to the question of how much expressive power a data model should support. The problem lays in the fact that the complexity of reality is always beyond the expressive power of any data model. However, a very expressive model may be too complex and could eventually be rejected by users. Therefore, user comfort is a mandatory goal for conceptual data models. Since users must be able to participate in the database design effort they need to understand the modeling concepts and rules. Thus, an easy-to-understand visual support with clean, intuitive visual notations is the best means to facilitate discussion and assessment of a schema definition.

Simplicity and expressive power may be seen as contradictory requirements. The former looks for fewer constructs, the latter asks for more. Yet it is possible to combine both by following a golden principle: orthogonality. This principle says that the best way to handle multidimensional issues is to decompose them according to different facets, so that each facet can be handled independently from the other. Data modeling can be seen as a multidimensional issue, as the designer has to cope with different modeling dimensions: data structures, space, time, and representation, to name a few. The benefit of orthogonality is that understanding and solving one facet at a time is much simpler than solving all facets together.

The availability of an associated conceptual data manipulation language for querying and updating the data is a major plus. It allows users to perform all their database interactions using a single paradigm. Currently, we are far away from this ideal situation: Database users think in terms of ER or UML diagrams for schema definition and they have to speak relational SQL for data manipulation.

Finally, when addressing the requirements for data models for spatio-temporal databases, a few more requirements need to be considered. Regarding space modeling, it is essential for a conceptual data model to provide concepts for the description of both the discrete and the

continuous view of space, in a seamlessly integrated way. Both views are important for applications, which may use one or both simultaneously. Regarding time modeling, an additional requirement is the capability to address both transaction and valid time.

The data model described in this chapter has been designed to fulfill all of the above goals. The model is named MADS (for Modeling Application Data with Spatio-temporal features) A detailed presentation of the model can be found in [3. 4].

2. Thematic Data Structures

2.1 Object Types

Database objects or instances represent the real-world entities of interest to the applications. Object types group set of objects that, from the application point of view, may be considered as similar. An object type defines a set of properties of interest, i.e., attributes and methods. Fig. 1 illustrates an example of an object type. The population of an object type is defined as the set of instances of the type.

Attributes may be of two kinds. Those directly holding a value, e.g., number for AvalancheEvent, are called simple attributes. Those conveying a structuring concept, e.g., witnesses are called complex attributes. A complex attribute denotes a set of attributes that are either simple or complex. Every simple attribute is associated to a data type defining a value domain (i.e., the set of allowed values for the attribute) and the set of operations allowed on values in the domain.

Attribute cardinality denotes the number of values that an attribute may hold. Cardinality is defined by a couple numbers (min, max) defining the minimum and maximum number of values. Cardinalities define attributes as mandatory or optional depending on whether an object instance may be created without such attributes. Furthermore, cardinalities determine whether attributes are monovalued or multivalued, i.e., whether they hold at most one or multiple values. Multivalued attributes may be split into distinct categories, depending on the kind of collection they may hold, i.e., set, bag, or list.

To make sure that two different instances of an object type are distinguishable, even if they hold the same value, MADS assumes that each instance is identified by a system-defined attribute, called the object identifier, or in short oid. In addition, user-defined identifiers or keys express the fact that values of an attribute are unique within an object type. One or more keys can be defined for each object type. Fig. 1 shows the specification of the key, identified by the key icon, as consisting of the single attribute number.

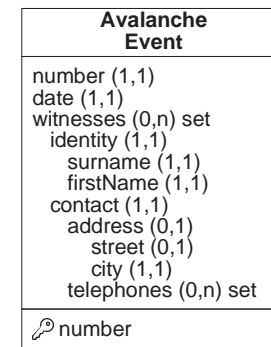


Fig. 1. A diagram of an object type

While attributes convey descriptive information, methods attached to object types, specify the operations that are specifically defined for the type. A method is specified by defining its signature (i.e., its name and the list of its input and output parameters), and its body (i.e., the actual code that will be executed when the method is activated).

2.2 Relationship Types

Objects are interrelated by relationships that provide paths to complementary information about the object. Relationships represent real-world links that are of interest to the application. As for object types, relationships that from the application perspective are considered as having the same characteristics are grouped in relationship types, where each relationship type conveys a link between two or more object types, as shown in Fig. 2. Associations in MADS are n-ary ($n \geq 2$). The set of instances of a relationship type constitutes its population.

MADS identifies two basic kinds of relationship types, association and multi-association, described next.

Associations are the most universally-known kind of relationship type. An association relationship type (referred to as an association type or as a relationship type) is a relationship type that links two or more object instances without imposing any specific semantics on the link. Fig. 2 shows a binary relationship type. The lines connecting the relationship to the linked object types materialize the roles within the relationship type. In a cyclic relationship type the same object type may be linked by two (or more) roles. For cyclic relationship types, roles linking the same object type must be equipped with a role name.

Cardinality constraints characterize each role of the relationship. For each role, its minimum and maximum cardinalities define the number of relationship instances that may link an instance of the object type linked by the role. For instance, cardinalities in Fig. 2 mean that an observer may have never observed an avalanche, and that an observer may have observed any number of avalanches, where these observations have an application-defined order. To make sure that these two (or more) instances of a relationship can be differentiated, MADS adopt a relationship identifier (shortly, rid). As object types, relationship types may be described by properties (attributes and methods).

In some situations the basic association relationship does not allow to accurately represent real-world links existing between objects. Fig. 3 shows two maps of the same area at different scales. Focusing on the area within the superimposed circles, we can see that the left-hand map shows five aligned buildings whereas at the same location the right-hand map shows only three buildings. Suppose now that the application stores the five buildings in the left-hand map as



Fig. 2. A diagram showing a relationship type linking two object types

instances of the BuildingScale15'000 object type, and the three buildings in the right-hand map as instances of the BuildingScale25'000 object type. If the application requires to be able to correlate cartographic representations, at different scales, of the same real-world entities, this means creating a link between the 5 instances of BuildingScale15'000 on one side and the 3 instances of BuildingScale25'000 on the other side.

In order to be able to represent such situation MADS provides the multi-association construct. A multi-association relationship type is a relationship type that links, for each role, a non-empty set (or list) of instances of the linked object type. Consequently, each role in a multi-association relationship type bears two pairs of (minimum, maximum) cardinalities. A first pair is the conventional one that, as in association relationship types, defines for each object instance, how many relationship instances it can be linked to via the role. The second, additional, pair defines for each relationship instance, how many object instances it can link with this role. Its value for minimum is at least 1. Using a multi-association relationship type (visually represented by a double ellipsis), the above correspondence between cartographic buildings can be modeled as shown in Fig. 4.

Apart from cardinality constraints, multi-associations relationships share the same features as association relationships. They may be n-ary, cyclic, and bear properties. Their instances bear a unique and immutable rid.

2.3 Is-a Links

The is-a link, or the generalization/specialization relationship allows to relate a generic type (the supertype) and a specific one (the subtype) stating that they convey different representations of the same real-world objects. In the example of Fig. 5, the object type representing hazard zones is specialized in three subtypes for representing landslides, erosions, and avalanches zones.

Is-a links bear a population inclusion constraint enforcing that every object instantiated in the subtype is also instantiated in the supertype. The inclusion semantics naturally induces another well-known characteristic of is-a links: property inheritance, where all properties and links defined for the supertype also hold for the subtype. An immediate benefit of inheritance is type substitutability, i.e., enforcing the fact that wherever an instance of a type can be used in some data manipulation, an instance of any of its subtypes can be used instead.

Sometimes application requirements need to deviate from the standard inheritance rule where the definition of a property and its value are the same for the supertype and the subtype. As a first alternative refinement modifies the definition of the inherited property by making it more restrictive, but the value remains the same in both the supertype and the subtype. Another

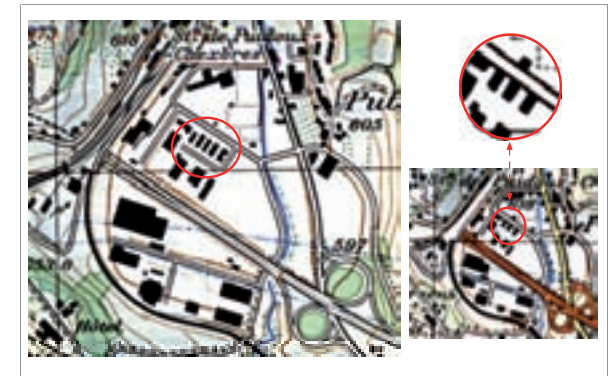


Fig. 3. An example of a data management situation that calls for using a multi-association relationship.



Fig. 4. An example of a multi-association relationship type.

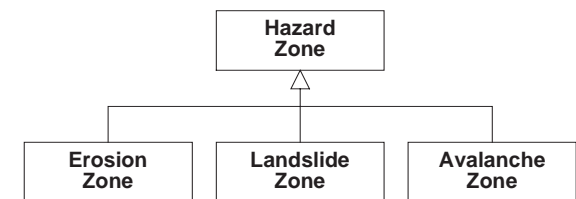


Fig. 5. Object types connected by is-a links.

alternative arises when applications require that instances in the subtype show a different value or behavior for an inherited property than the instances in the supertype. Redefinition aims at keeping substitutability of the property in the supertype with the corresponding property in the subtype for ensuring dynamic binding. Overloading relaxes this concern. For example, redefining in *AvalancheZone* the geometry attribute inherited from *HazardZone* allows keeping two different (e.g., at different resolution) but compatible specifications of the surface covered by the same zone. In overloading, the local definition and, in case of an attribute, the local value, simply replace the inherited ones, without any compatibility requirements.

MADS supports is-a links between relationship types, with the same characteristics (population inclusion semantics, property and role inheritance, possibility to add local properties). In Fig. 6 the designer wants to create a separate relationship type for observations of avalanches that are made by observers at the time of the avalanche (rather than after the avalanche). A sub-relationship type may have additional properties with respect to the super-relationship type. The diagram shows that both roles in *RealTimeObserves* have the same cardinalities as in *Observes* (plainly inherited roles are not redrawn in the sub-relationship type).

When allowing is-a links among relationship types, roles may be inherited with refined (i.e., more restrictive) cardinalities in the subtype. Further, as shown in Fig. 7, existing roles may be refined as associated to a subtype of the otherwise inherited object type. In this case the cardinalities of the role and the other role are inherited by *TrustedObserves* without modification. The design ensures that only observations made by accredited observers are registered as instances of *TrustedObserves*. Finally, new, local roles may be added with their respective object types (e.g., a binary relationship type may have as subtype a ternary relationship type).

2.4 Relationship Semantics

With this section we introduce a number of additions that can be used, in isolation or together with other additions, to give a specific semantics to relationships.

Aggregation relationships denote relationships that link an object seen as a whole with its component objects. As illustrated in Fig. 8, object types may be organized into aggregation hierarchies containing several levels. MADS associates specific terms, *isComponentOf* and *isComposedOf*, as semantic adornments to the roles to make explicit which object is the component and which object is the composed. Notice that aggregations are binary relationship types and they may be cyclic.

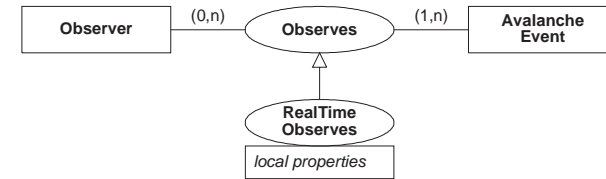


Fig. 6. A diagram showing an is-a link between two relationship types (with plain inheritance).

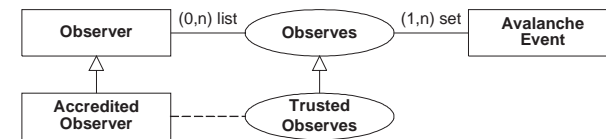


Fig. 7. A diagram showing a relationship subtype refining a role to link a subtype of the original object type.

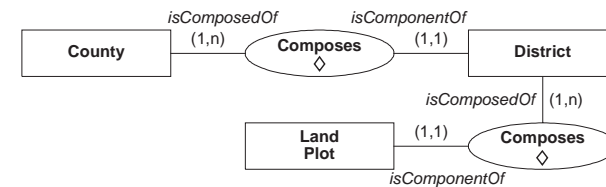


Fig. 8. An aggregation hierarchy in MADS, showing semantic adornment of roles. The rhomboid icon has been chosen to denote the aggregation semantics.

Transition relationships [5] allow to keep track of the dynamic evolution of objects in the database, i.e., how they appear and disappear within the populations of object types. They are binary association relationship types whose roles are given specific semantic adornments, *isSource* and *isTarget*, to specify the direction of the evolution. They may bear properties that describe information of interest about the evolution process. Fig. 9 shows a transition relationship type allowing to record information on acquisition of buildings by public organizations, e.g., who has taken the decision to use this public building as a crisis building and when the decision was taken. Transition relationships are constrained by the fact that they only relate instances with the same identity. The transition may leave the source instance in existence or require that it ceases existence when migrating to the target type.

Generation relationships [6] record information about creation of entities of a given type from other entities of the same or different type. An example is provided by land restructuring processes, where a set of land plots is reconfigured to form a different set of new land plots (cf. Fig. 10). The generation semantics induces semantic adornment of roles: *isSource* (designating the type of the generator instances) and *isTarget* (designating the type of the generated instances). In this particular example the generation semantics is associated with a cyclic multi-association relationship type. Generation relationships may bear properties. As several entities of possibly different types may concur in the process of creating one or several new entities of possibly different types, generation relationships are n-ary. The instances they link have different oids as they represent different real-world entities.

3 Spatio-Temporal Data Structures

3.1 Locating Objects in Space and Time

The intrinsic characteristic of spatio-temporal database systems is that they allow locating objects in space and in time. Locating an object means specifying the place the object occupies with respect to a given framework that holds all the possible places for an object. In GIS terminology, the place is termed the object extent, defined as the set of points that the object occupies in space (spatial extent) and in time (temporal extent). In order to efficiently define manipulate and query spatial and temporal extents, specific data types must to be provided. Tables 1 and 2 list the spatial and temporal data types supported by MADS, along with their associated icons. The spatial and temporal data types come with associated operations and predicates that users may use when writing their queries.

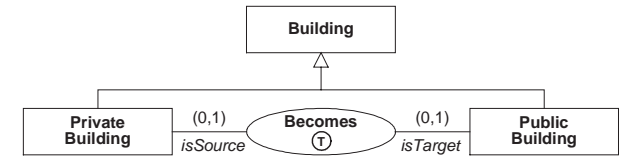


Fig. 9. A transition relationship type used to keep information about the transition from private to public buildings. The encircled T icon denotes transition semantics.

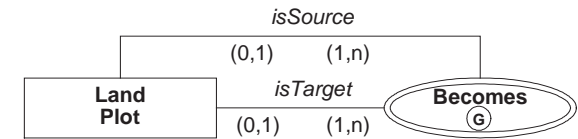


Fig. 10. Modeling land restructuring with a cyclic multi-association relationship type with generation semantics, denoted by the encircled G icon.

Spatial data types	Icon	Spatial data types	Icon
Geo		SimpleGeo	
Point		Line	
OrientedLine		Surface	
SimpleSurface		ComplexGeo	
PointBag		LineBag	
OrientedLineBag		SurfaceBag	
SimpleSurfaceBag			

Tab. 1. Spatial data types in MADS, and associated icons.

3.2 Describing Space and Time Using the Discrete View

The approach to define the spatial and temporal extents of the phenomena of interest using specific data types is referred to as the discrete view (or object view) of space and time. In the discrete view, space regions and time segments are either occupied by some autonomous entities, or are empty. In MADS space and time description is orthogonal to data structure description, which means that a phenomenon may be enhanced by spatial and temporal features whatever data structure (i.e., object, relationship, attribute) has been chosen to represent it.

A spatial (temporal) object type is an object type that holds spatial (temporal) information pertaining to the object itself as a whole. For instance, in Fig. 11 a) both object types are spatial while only LandPlot is temporal. Following common practice, we call spatio-temporal an object type that either has both a spatial and a temporal extent, separately, or has a time-varying spatial extent (i.e., its spatial extent changes over time and the history of extent values is recorded). Spatial and temporal information at the object or relationship type level is kept in dedicated system-defined attributes: geometry for space and lifecycle for time.

A spatial (temporal) attribute is a simple attribute whose value domain belongs to one of the known spatial (temporal) data types. A spatio-temporal attribute is a time-varying spatial attribute. Each object and relationship type, whether spatio-temporal or not, can have zero or several spatial, temporal, and spatio-temporal attributes. For instance, in Fig. 11 b) the LandPlot object type includes, in addition to its spatial extent, a spatial attribute buildings holding the spatial extent of all its constructed areas.

Spatial, temporal, and spatio-temporal relationship types hold spatial and/or temporal information pertaining to the relationship as a whole, exactly as for an object type. For instance, a Crosses spatial relationship type may be defined to hold the spatial extent covered by the intersection of two roads.

Temporality associated to object/relationship types or to attributes can be given two different interpretations. Transaction time keeps information on when some data element was stored in and deleted from the database. On the other hand, valid time conveys information on when a given fact, stored in the database, is considered valid from the application point of view. MADS supports valid time, which is the most usual requirement for the applications we have dealt with.

Temporal object or relationship types (cf. Fig. 12) allow users to keep the lifecycle of their instances. It is important for many applications to allow the membership of an instance in an object or relationship type to be suspended and reactivated. This allows describing situations like a professor temporarily leaving for a sabbatical. Consequently, in MADS a lifecycle is described by a peculiar time-varying attribute associating to each instant of the time domain one of the four possible status values: scheduled, active, suspended, and disabled.

Temporal data types	Icon	Temporal data types	Icon
Time	⌚	SimpleTime	⌚ _s
Instant	⌚	Interval	🕒
ComplexTime	⌚ _c	InstantBag	⌚
IntervalBag	🕒	TimeSpan	🕒

Tab. 2. Temporal data types in MADS, and associated icons.

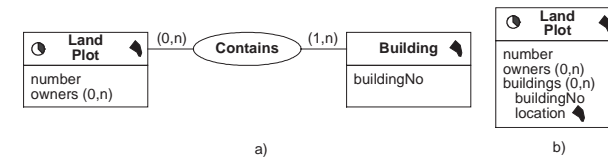


Fig. 11. Alternative schemas for land plots and buildings.



Fig. 12. Temporal object and relationship types.

As a consequence of capturing the lifecycle for instances of temporal types, the database may keep instances that are valid in the past, presently, and in the future. On the contrary, usual non-temporal types keep only currently-valid instances. For example, the object types as well as the relationship type in Fig. 12 are temporal. The temporal icons specify the temporal data type associated to the active state. Thus, in the example both observers and their assignments to avalanche monitored zones may be suspended and reactivated later on, while avalanche monitored zones have an active state which is continuous.

3.3 Space, Time, and Is-a Links

Generalization links may relate spatial and non-spatial object types. Any subtype of a spatial object type inherits the geometry of its supertype. For example, in Fig. 13 a), private buildings bear the same geometry they have when seen as generic buildings. Conversely, a non-spatial object type can have a spatial subtype: e.g., only cars equipped with a GPS system have a spatial extent as in Fig. 13 b).

The refinement, redefinition, and overloading mechanisms seen in Sect. 2.5 allow adjusting inheritance of spatial and temporal features to application’s needs. Overloading can be used to model different spatial representations of the same real-world entity at different scales, as in Fig. 13 c). Objects of the subtype Road1:20’000 have two geometries: the one inherited from the supertype and the locally redefined one. Refinement allows attaching a more specific spatial or temporal data type to the subtype. For example, in Fig. 13 d) the generic concept hazard zone is used to describe both landslide zones and avalanche zones, but for operational reasons landslide zones are to be represented as simple surfaces while avalanche zones are to be represented as a set of oriented lines.

Similar considerations apply to temporal specifications. Subtypes of a temporal supertype are automatically temporal too (lifecycle is inherited), and non-temporal supertypes may have temporal subtypes. Further, the lifecycle may be overloaded or redefined in the subtype.

3.4 Constraining Relationships with Space and Time Predicates

The links among spatial and temporal object types play an important role in the description of spatio-temporal phenomema. For instance, in Fig. 14 the observations of avalanches by an observer are made only while the observer is on duty. We call constraining relationship type this kind of relationship type, bearing a specific spatial or temporal predicate on the geometries or lifecycles of the linked objects. Like any relationship type, they support attributes and methods, allowing designers to describe properties of spatial and temporal links.

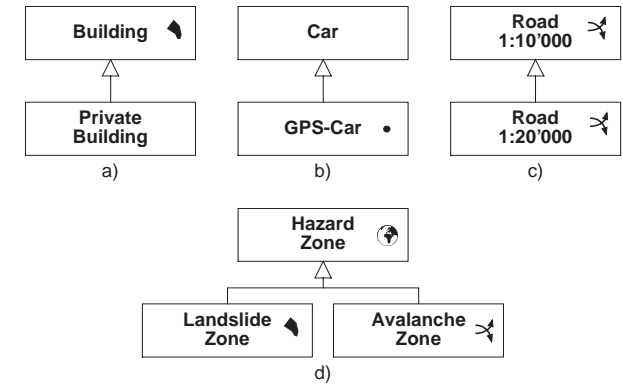


Fig. 13. Inheritance, refinement, redefinition, and overloading of spatiality: a) normal inheritance, b) adding local geometry, c) geometry redefinition or overloading, and d) geometry refinement.



Fig. 14. A synchronization relationship type of kind SyncWithin.

Topological kind	Icon	Topological kind	Icon
TopoDisjoint	●○	TopoTouch	●●
TopoOverlap	●●	TopoCross	⊗
TopoWithin	●○	TopoEqual	◎
TopoGeneric	⊕		

Tab. 3. MADS topological relationship types with specific icons.

MADS supports topological relationships for the spatial dimension and synchronization relationships for the temporal dimension. For the most frequently-used constraining relationships MADS define specific icons, shown in Tables 3 and 4.

MADS allows associating multiple semantics to a relationship type. For example, a relationship type between spatial objects that has aggregation semantics often also conveys a topological (TopoWithin) semantics. Topology and synchronization semantics may also characterize the same relationship type, thus enforcing both a spatial and a temporal constraint. An example is shown in Fig. 15.

3.5 Describing Space and Time Using the Continuous View

Beyond the discrete view, there is a need to support another perception of space and time: The continuous view (or field view). This view focuses on the description of phenomena that are observable over a given space/time extent and are not related to any specific object within the extent.

An attribute is said to be space-varying (resp. time-varying) if its value changes according to the point in space (resp. instant in time) into consideration. A typical example of space-varying attribute is land elevation. Attributes may be both space-varying and time-varying, called also spatio-temporal attributes. For example, the value of land occupation depends on both the point in space and the instant in time that are being considered. Fig. 16 shows examples of varying attributes and their associated notation in MADS. Varying attributes are defined by a function whose domain in spatial and/or temporal extent. The range of the function can be any set of values (e.g., Real for temperature, Integer for rainfall). The range may be monovalued or multivalued; it may be simple or complex.

A topological relationship may link moving or deforming objects, i.e., spatial objects whose geometries are time varying. Fig. 17 shows such an example. In this case two possible interpretations can be given to this predicate, depending on whether it must be satisfied either in at least one instant or in every instant belonging to both time extents of the varying geometries [7]. Applied to the example of Fig. 17, the two interpretations result in keeping in the relationship either the land plots intersecting a risk zone for at least some time, or the land plots that always intersects a risk zone.

Synchronization kind	Icon	Synchronization kind	Icon
SyncPrecede	⊲	SyncMeet	⊲⊳
SyncWithin	⊲⊳	SyncOverlap	⊲⊳
SyncStart	⊲⊳	SyncFinish	⊲⊳
SyncEqual	⊲⊳	SyncDisjoint	⊲⊳
SyncGeneric	⊲⊳		

Tab. 4. MADS synchronization relationship types with specific icons.



Fig. 15. A topological (TopoOverlap) and synchronization (SyncOverlap) relationship type.

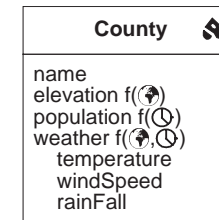


Fig. 16. A County object type with a space-varying attribute (elevation), a time-varying attribute (population), and a space- and time-varying attribute (weather).



Fig. 17. An example of topological relationship that links spatial object types with deforming geometries.

4 Supporting Multiple Perceptions and Multiple Representations

4.1 Rationale for Multiple Representations

Databases store representations of identifiable real-world phenomena that are of interest to a given set of applications. However, while the real world is supposed to be unique, its representation depends on the intended purpose. A known difficulty in database design is to reconcile divergent requirements of the applications sharing the same database. These requirements vary both in terms of what information is to be kept and in terms of how the information is to be represented. To support such heterogeneity of perceptions, the database has to be able to hold multiple representations of the same real-world phenomenon (cf. Fig. 18).

Geographical applications show additional requirements in terms of multiple representations.

One of them relates to spatial resolution, defined as the smallest granule of space that can be individually denoted. Choosing an appropriate resolution level is essential in map production. The ideal setting would be to keep the geometry information at the most precise resolution, and automatically compute geometries at less precise resolutions from those at more precise ones, a process called cartographic generalization [8]. Unfortunately, there is no complete set of algorithms that automatically derives a map at some resolution from a map at a more precise resolution. Thus, map production systems need to keep the geometries of objects at different resolutions.

Geographical databases are also subject to classical semantic resolution differences, where an application may see a road as a single object, while another one may see it as a sequence of road sections, each one represented as an object. As another example, geographical databases need to support hierarchical value domains for attributes, where values are chosen depending on level of detail. Fig. 19 shows a typical example.

4.2 Multiple Representation Modeling

Perception is guided by a specific interest in data management and determines a corresponding representation fitting that interest. In MADS the set of identifiable perceptions supported by a database are referred to as perception stamps, or just stamps, and are denoted as s_1, s_2, \dots, s_n . From data definitions (metadata) to data values, anything in a database relates to one or several perceptions. Stamping an element of a schema defines for which perceptions the element is relevant.

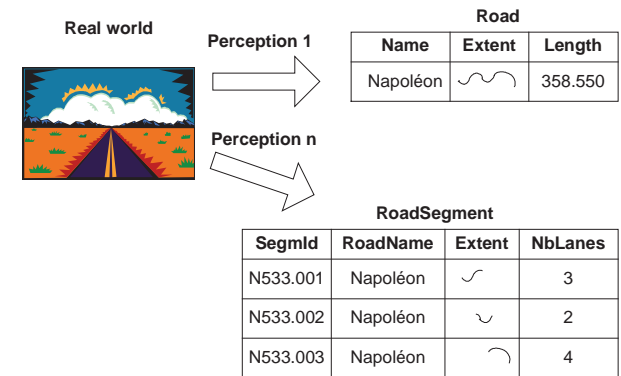


Fig. 18. Different perceptions of the same reality, in this case leading to different representations.

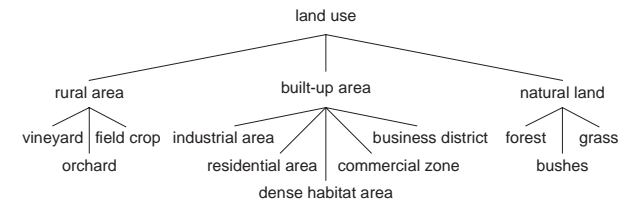


Fig. 19. An example of a hierarchical domain.

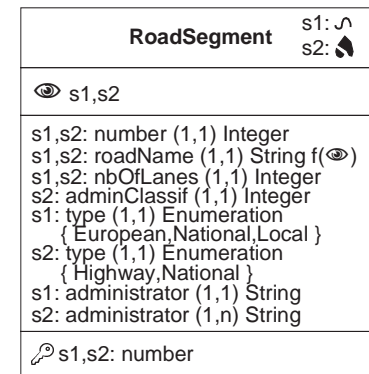


Fig. 20. An illustration of a bi-representation type, bearing stamps s_1 and s_2 .

There are two complementary techniques to organize multiple representations. One solution is to build a single object type that contains several representations, the knowledge of “which is which” being provided by the stamps of the properties of the type. Following this approach, in Fig. 20 the designer defines a single object type, RoadSegment, and associates to it the stamps identifying the two perceptions, say s1 and s2, identified using the \square icon. We say RoadSegment is a perception-varying object type, as the actual representation of road segments changes from one perception to another.

Another solution to organize alternative representations is to define two separate object types, each one bearing the corresponding stamp (cf. Fig. 21). The knowledge that the two representations describe the same entities is then conveyed by linking the object types with a relationship type that holds a specific inter-representation semantics (indicated by the \circ icon). In this example the same real-world road segment is materialized in the database as two object instances. Instances of the relationship type Corresponds tell which object instances represent the same road segment.

The actual representation of instances of perception-varying object types changes from one perception to another. Consider the multi-representation object type RoadSegment (cf. Fig. 20) with stamps s1 and s2. The spatial extent of the type is represented either as a surface (more precise description, stamp s2) or as a line (less precise description, stamp s1) depending on resolution. Further, representation s1 needs attributes road segment number, road name, number of lanes, type, and administrator (denoting the maintenance firm in charge). Representation s2 needs attributes road segment number, road name, number of lanes, administrative classification, type, and administrator. While the road segment number and the number of lanes are the same for s1 and s2, the name of the road is different, although a string in both cases. For instance, the same road may have name “RN85” in representation s1 and name “Route Napoléon” in s2. We call this a perception-varying attribute, identified as such by the $f(\square)$ notation. The road segment type takes its values from predefined lists, the lists being different for s1 and s2. Finally, s2 may record several administrators for a road segment, while s1 records only one. Moreover perceptions s1 and s2 share a common key, the attribute number, i.e., no two instances, belonging to the same perception or different perceptions, may have the same number value.

Stamps may be also associated at the instance level. This allows defining different subsets of instances that are visible for different stamps among those supported at the type level. Thus, multi-perception types have a system attribute called perceptions allowing to keep track of the visibility of its instances. For example, as the object type RoadSegment in Fig. 20 has two

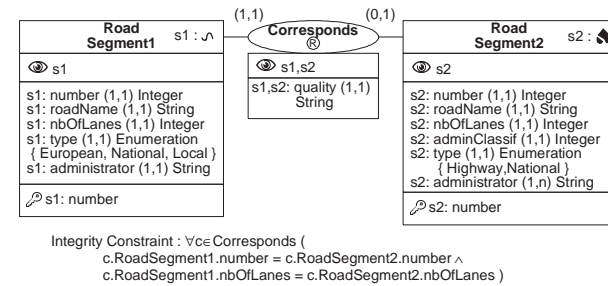


Fig. 21. The RoadSegment type (from Fig. 20) split into two mono-representation object types and an inter-representation relationship type.



Fig. 22. A relationship type with perception-varying semantics.

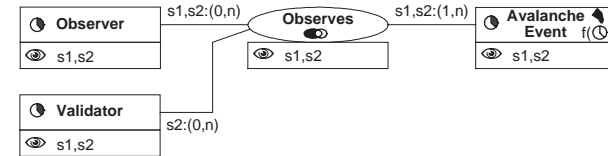


Fig. 23. A relationship type with an additional role specific to perception s2.

stamps, it is possible to define instances that are only visible to s1, instances that are only visible to s2, and instances that are visible to both s1 and s2.

Relationship types are as dependent on perception as object types are. Therefore they may have different representations, and representations may be stamped with the same semantics and according to the same rules as for object types. Moreover, the structure (roles and association/multi-association kind) and the semantics (e.g., aggregation, topology, synchronization) may also have different definitions depending on the perception.

Fig. 22 shows an example of different semantics, where the designer defined the relationship GivesAccess as 1) a topological adjacent relationship type for perception s1, and 2) a plain relationship without any peculiar semantics or constraint for perception s2.

The kind association/multi-association of a relationship type may also depend on the perception. Similarly, the roles of a relationship type may also be perception dependent. Further, the same relationship type may be a binary relationship type in one perception and a ternary relationship type in another perception. For example, Fig. 23 shows that an observation is perceived in s1 as a relationship between an observer and an avalanche event, while perception s2 sees the same observation as also involving a validator having validated the observation.

5 Conclusion

This chapter presented the modeling concepts underlying the MADS conceptual data model. The objective that influenced most the design of MADS is that of orthogonality between the four dimensions: structural, spatial, temporal, and multi-representation. This allows building a model that is both simple (since these concepts are independent) and powerful (since these concepts may be freely combined). Orthogonality also allows answering to another fundamental requirement, the possibility to mix in one application classical and/or spatio-temporal and/or multi-represented data. To support these four modeling dimensions a set of data types has been defined. Another fundamental advantage of MADS is that it comes with an associated data manipulation language, which is also at the conceptual level. Thus, users can define and manipulate (i.e., query and update) the database using the same conceptual formalism. Such facilities are usually not supported by current conceptual approaches.

MADS has been tested in several applications. As an example, [4] presents the Risks application used as test case in the MurMur project and develops its complete conceptual schema. The advantages of MADS in terms of conciseness and readability appeared evidently. Designers of the application schema and corresponding queries also appreciated the comfort of not having to take into consideration the technical particularities of existing GISs or DBMSs. The project

developed a set of prototype tools supporting the MADS model, for schema definition as well as for query definition and visualization, thus making the approach operational in enterprise.

References

- [1.] P.P. Chen, "*The Entity-Relationship Model: Towards a Unified View of Data*", ACM Transactions On Database Systems, 1 (1) 1976: 9–36
- [2.] J. Rumbaugh, I. Jacobson, and G. Booch, "*The Unified Modeling Language, Reference Manual*", 2nd edition. Addison Wesley, 2005
- [3.] C. Parent, S. Spaccapietra, and E. Zimányi, "*The MurMur Project: Modeling and Querying Multi-Represented Spatio-Temporal Databases*", Information Systems, available online April 2005
- [4.] C. Parent, S. Spaccapietra, and E. Zimányi, "*Conceptual Modeling for Traditional and Spatio-Temporal Applications : The MADS Approach*", Springer, 2006
- [5.] G. Hall and R. Gupta, "*Modeling transition*", [in] Proceedings of the 7th International Conference on Data Engineering, ICDE'91. IEEE Computer Society Press, 1991, pp. 540–549
- [6.] R. Gupta and G. Hall, "*An abstraction mechanism for modeling generation*". [in] Proceedings of the 8th International Conference on Data Engineering ICDE'92, 1992, pp. 650–658
- [7.] M. Erwig and M. Schneider, "*Spatio-Temporal Predicates*", IEEE Transactions on Knowledge and Data Engineering, 14(4)2002: 881–901
- [8.] R. Weibel and G. Dutton, "*Generalizing spatial data and dealing with multiple representations*", [in] P.A. Longley, M.F. Goodchild, D.J. Maguire, D.W. Rhind, eds., Geographical information systems: Principles, Techniques, Management and Applications, vol. 1, pp. 125–155. 2nd edition. John Wiley, 1999

Cultural Heritage: surveying, integrating heterogeneous data and sharing knowledge over the Web

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A correct management of the various aspects of our knowledge of architectural heritage and the evaluation of its state of conservation, which are required for making a plan, implementing it and verifying the results, can only be achieved by constantly matching the specificity of the monument, after its exact geometry has been restored, with the elements obtained by historical-architectonic analysis, the survey of the structure, building techniques and materials used, including those which describe its material status, considering individual buildings as a whole and systems of buildings as a group in its context

The studies outlined here were carried out to show how the integrated representation of the monument's geometry together with the morphology and distribution of the damage, the component materials and their physical characteristics, the historical-architectonic analysis and environmental factors can be used to facilitate our understanding of degradation processes.

Identifying the Information & Communication Technology (ICT) as being able to create environments that are typically suitable for the aims pursued and to use as an operating instrument, it was decided to translate the theoretical disciplinary model into a computer-based procedure in which the functions specific to the GIS- Geographic Information Systems- were transposed to an architectonic scale.

Key Words

Historical Buildings, Decay, Restoration, Knowledge, Survey, GIS, Web-GIS, Virtual Reality.

Categories

H.4.m, J. 5.

1 - Introduction

The analysis and understanding of processes of decay, in the case of historical buildings and monumental architecture, call for an interpretative overview encompassing data which stem from different areas of study but are globally interrelated and constitute essential elements for the purpose of assessing the state of preservation.

Geometric survey is a fundamental stage in a correct approach to surveying, defined as the complex of actions required to obtain an “integrated knowledge” of the architectural artefact to be conserved and protected.

As part of architectonic restoration it is necessary to define the different knowledge paths and relative data bases, identify the reciprocal interactions in order to promote a complex interpretative action on the state of conservation of the historic building object.

This is done by using different data acquisition and recording procedures consistent with their nature and referring to the geometric, structural and material configuration, to the study of the historical and architectonic features, as well as to the understanding of the formative processes and the analysis of the pathologies of degradation as a function of the typologies of the constituent materials. Likewise, as regards the successive phases of the definition of the intervention and its execution, it is necessary to guarantee a rigorous approach to the knowledge and the management of the data.

A fundamental role is played by the dissemination and utilizability of information.

The introduction of Information and Communication Technology (ICT) also in the sector of Cultural Heritage has led, in recent years, to a still limited and self-conscious transformation of the methods of approach to specific issues in the field of both data acquisition and in that of the subsequent data processing and management (*cf.* [1]).

In other words, there is still no consistent cultural growth in this direction, particularly in those public and private bodies that play a major role in the process of safeguarding and enhancing these assets.

Conversely a number of investigative and experimental initiatives carried on, in the research field are evidence of a fruitful activity aimed at providing the various stages of the process specific to conservation and protection, also at the operational level, with the innovative tools that modern technology can now offer in a very wide range of disciplinary sectors. The implementation of the Internet has made available huge quantities of data in all fields of human knowledge, encouraging the sharing of ideas, studies and information, and at the same time making it possible also for non experts to approach and discover fields of learning that would otherwise be very difficult to access.

The issue to be reflected upon consists of how the theme of identifying innovative techniques and methods applied to the sector of the conservation and promotion of Cultural Heritage makes up the central node of the question of the full and conscious introduction of the tools specific to ICT into the area of the so-called humanistic disciplines, wherever the latter already make use of scientific equipment to address the complex problems of “measurement” and “diagnosis” following more correct and objective methods than in the past.

Indeed, the manifold nature of the variables involved in a systematic approach to the entire process of conservation and, in particular, the complex nature of the phenomena that cause the alterations, demands a specific knowledge thereof, the capacity to store and manage data and the definition of computing procedures able to support the global knowledge and diagnosis process. The sum total of these data, which are by nature heterogeneous, must be collected and processed and made available, using suitable specific modalities, to both the general public and to the specialist professional.

At the outset, it is useful to summarise highlighting the salient aspects involved in a correct management of the preliminary stages of the projected conservation of an asset of historical and artistic interest.

Speaking about knowledge of an historical building state of conservation as an essential preparatory phase of the conservation action, one is clearly referring to a systemic process that follows a logical development in successive and/or contemporary phases. In brief, neglecting the means used (whether conventional or ICT based), these consist of:

- acquisition of heterogeneous data,
- pre-processing of data,
- data processing,
- setting up suitable environments for the (possibly integrated) management of the data and for their transferability,
- synthesis enabling the state of conservation to be evaluated,

in which, typically, the pre-processing and processing phases are those in which a high degree of contemporaneous treatment is possible. Likewise, the structuring of the management and transfer environments may be carried out “autonomously” and in parallel, provided that the different typologies are known (description, formats, dimensions, etc.) of the data to be organised and transferred. Only at the end of this process will the necessary calibrating of the prepared environments be carried out in order to check its correct function, when the real data will ‘populate’ the actual environments.

This implies the need to use properly applied technologies in all phases of the entire process of knowledge, conservation, promotion and protection.

Lastly, focusing attention on the subsequent stage of enjoying the Cultural Heritage, it will be necessary to address a widely debated topic that inevitably leads to considerations regarding the sustainability of this enjoyment which once again, precisely through ICT technologies, in particular multimedia technology, can find a vehicle with which to share and transfer knowledge addressed to different types of users and thus lightening or at least diversifying the physical “wear” on the asset.

2 - Surveying

Currently, the consolidated procedures of terrestrial photogrammetry draw considerable advantage from digital systems. These systems open up extremely interesting horizons within which the data referring to geometric consistency is combined, without loss of rigour, with other qualitative, morphological and colour information specific to the photographic document.

The present paragraph illustrates the methodology adopted and the results obtained during the testing of innovative systems of stereoscopic photogrammetric surveying used in a joint research project carried out by CNR Institute for Technology Applied to Cultural Heritage – CNR ITABC (see note 1.). This project represented a good opportunity to test these innovative instrumental survey systems, which had been developed in recent years and are capable of optimizing acquisition time, simultaneously guaranteeing a reliable result.

Moreover, owing to the large scope and the characteristics of the consultation environment, it mostly may be considered unique as well as fully suited to satisfy Public Administration needs of protection and conservation.

The artefact investigated in the present study consists of the entire ancient Roman city walls of Aosta (Augusta Praetoria). The stereophotogrammetric coverage of this monument became necessary for the purpose of preparing a scientific basis of geometric data, finalized to evaluate the state of conservation and to plan the subsequent conservative restoration actions.

The city walls, still today almost entirely conserved (see Fig. 1), have a total length of over five kilometres between the external and the internal side; they are rectangular in shape, and their sides measure respectively 727.5 meters and 574 meters (see note 2.).

A quick non-conventional stereo-photogrammetric system has been applied. It guarantees reliability from the point of view of measurement rigour, as well as satisfying characteristics of considerable flexibility and ease of use (*cf.* [2]). This consists of a single camera system that transfers into digital form the majority of bicameras advantage, the lay-out of which

Note 1. CNR Institute for Technology Applied to Cultural Heritage (CNR-ITABC) and the Superintendence for Cultural and Environmental Heritage of the Valle d'Aosta, within the framework of the Protocol of Intent between the CNR and the Valle d'Aosta Autonomous Region (RAVA).



Fig. 1. Portion of wall belonging to the Aosta wall perimeter that delineates its conformation. [P. Salonia et al., Aosta city wall survey, CNR ITABC 2004-2005]

Note 2. The wall system, which dates back to the time of the foundation of Augusta Praetoria, appears with the classical layout reinforced by towers located at regular distances, some of which still well conserved despite the repairs carried out in successive periods. It is also interrupted, at the end portions of the *cardo* and the *decumano*, by four gates leading into the city, of which *Porta Praetoria* is a splendid example. From the construction point of view the walls are made of *opus caementitium* with a facing of squared travertine blocks that cement conglomerate made of river pebbles covered with mortar. Today only a few sections remain, the conservation of which is essential for an understanding of the construction technique used and the outer configuration of the facing itself.

corresponds to the settings of traditional stereocamera systems. The relative calculations and basic survey principles (*cf.* [3]) are applied without the limitations peculiar to conventional instrumentation and techniques.

The system applied on a small scale and to architectural objects of limited size should not require topographical support points. However, in order to verify the system itself, at the same time also a topographic survey of coordinates of significant points has been carried out with a total laser station, supported by a system of local polygonals linked to the main datum points of the topographic network of the city. This control operation has been important considering the difficult survey conditions and the length of the wall sections to cover, that is, in view of the fundamental need to boost the metric control of the construction over its considerable length. The surveying of the topographic points was also essential in order to perform the chaining of the individual stereoscopic models and obtain a unitary view of whole wall sections that could be explored in a specially configured 3D navigation environment.

The stereoscopic acquisition was performed using a special calibrated aluminium bar, mounted on a topographic tripod, on which is applied a sleigh, realized in special steel, supporting the photographic camera (see Fig. 2), which has been also calibrated (in this case a Nikon D-100 digital photcamera, with a 24 mm lens was used).

The sleigh, bound to flow on a rectilinear guide, allows the photcamera to be moved and secured in specific positions by being blocked using special holes drilled at fixed intervals on the bar (left and right photogram) representing the base of the stereoscopic pair.

Considering the specific nature of the object investigated and the need to make geometric and qualitative assessments (characteristics of the component materials, forms of degradation, state of conservation of external facing and internal cavity, etc), the decision to use a digital photcamera, rather than a conventional film camera, made it possible to avoid intermediate phases like development, printing and scanner acquisition. As mentioned above, in order to realize stereoscopic navigation environments (*i.e.* in 3D and thus with meaningful x,y,z coordinates) suitable for managing all the derived body of information, the entire stereoscopic coverage has been processed using a specific software preset for photogram orientation in order to obtain a geometrically controlled 3D raster model. The last one has been loaded in another software module where is possible the three-dimensional management (control, measurement and rendering) of the work under examination (see Fig.3).

For the processing of the stereoscopic models another digital photogrammetry software was used that was suitable for the case in question. This software allows the stereoscopic couples to be linked together in such a way that they can be explored successively and with the possibility of passing from one model to another without a break (*cf.* [4]).



Fig. 2. Calibrated aluminium bar on which the digital photcamera used for the photogrammetric survey was positioned.. [*www.menci.com*]

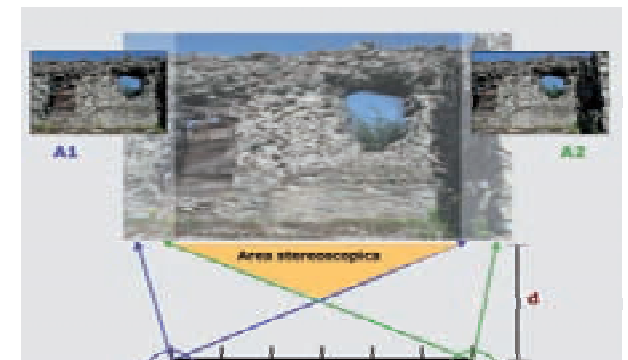


Fig. 3. Stereoscopic model of a portion of Aosta city wall. [P. Salonia *et al.*, *Aosta city wall survey*, CNR ITABC 2004-2005]

Note 3. The specificity and peculiarity of the work consist not so much in the application of an innovative system that, as mentioned in a preceding note, has already been widely tested in a wide range of other contexts (*cf.* [6]), as rather in the application of this fast 3D survey system on a large urban scale as is well represented in this case by the town walls of Aosta. It should indeed be emphasized that the attainment of the pursued objective has resulted in the creation of a powerful documentation tool. This tool makes it possible to

The software consists of three modules, each of which corresponds to given needs of photogram processing which may be summed up as follows:

- creation of internal, automatic or semiautomatic orientation of the photograms (Image Builder);
- creation of the absolute orientation of the photograms (SV Triangulation);
- creation of the model and stereoscopic rendering of the couples (SV Plotter).

For each photogram, both with orientation by couples and with block chaining, a corpus of specific data is created for each image. In addition to the image and orientation files it is also necessary to store a reference map (*.dxf file) which represents the unified framework of the photograms that is based on the evaluation of the results of both orientation by couples and triangulation. This chaining file can be imported into AutoCad and, in any subsequent graphics rendering phase, allows chaining of the 3D vectorializations of the construction (see note 3.).

3 - Integrating heterogeneous data

Over the past few years, the research undertaken has been focused on configuring a system capable of merging complex and heterogeneous data produced by using different acquisition methods specific to each particular phase of the fact-finding approach to the building within a custom-designed ICT environment (*cf.* [7]).

The product carried out consists of a software package called **ARKIS** (**A**rchitecture **R**ecovery **K**nowledge **I**nformation **S**ystem) developed in AVENUE, the ESRI programming language, and based on the ArcView engine. Its innovative aspect resides in the transfer of functions specific to the Geographical Information System - GIS – (*cf.* [8], [9]) to the architectonic scale of individual buildings, which is interpreted in the canonical forms of its graphical representation (plan views, elevations and sections), as a geographic area included inside a map.

ARKIS represents a modular tool consisting of several sub-systems each of which ensures different *levels* of knowledge through different degrees of detail, aimed at guaranteeing the *organization, representation* and *utilization* of the knowledge itself.

The basic structure underlying the entire methodological approach is represented by the extension of the georelational model applied to normal procedures typical of CAD and the more commonly used relational data bases. Consequently each data base of CAD objects and graphical entities acquires the *topological/vectorial features* of the GIS.

This option made it possible to interrelate the descriptive data with the graphic data, locating the information in a geometrically exact point (or area) using relational spatial positioning functions

investigate the whole construction with a very high degree of accuracy and with certain geometric rigour and, at the same time with levels of subsequent zooming to “approach the object” made possible by the high definition of the photographic apparatus which would be inconceivable in a visual inspection of the real object.

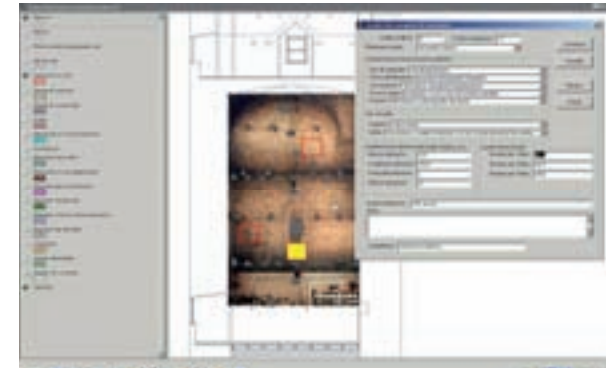


Fig. 4. ARKIS. Torre dei Capocci, Rome. The form containing data about decay situation of the area selected on the view [P. Salonia et al., case history for S. Scolastico Architecture degree, CNR ITABC 2000-2001]



Fig. 5. ARKIS. S. Vittoria Church (Monteleone, Rieti), a consultation data phase on decay situation [P. Salonia et al., case history for M. Bertini specialization, CNR ITABC 2002]

for the *geometric characterization of the information*, while respecting the reciprocal *topological* relationships among the various parts of the building.

The functions developed on purpose in Avenue language, allow to realize consultation and analysis paths in simple and interactive way, not always possible with the basic tools of the Arcview environment. All the alphanumeric information are in a relational external database, projected in a punctual way and connected to ARKIS through an ODBC channel (Object Date Base Connectivity). Criteria of integrity reference guarantee a correct hierarchical management of the information: the artifact system, individualized to territorial scale and assessed with apposite registry form, has been divided in subsystems (vertical structures, horizontal structures, coverages, staircases, elements of completion, decorative elements), on which the various detailed analyses relative to the constructive systems, to the state of conservation, to alterations of decay are articulated. Special tools allow to design directly on the vectorial or raster base regarding the prospect of the analyzed artifact (as on a section, on a plan or on an architectural detail) and at the same time to provide to the insertion of the alphanumeric data in the form that appears at the end of the drawing phase. The forms and the dialog windows, projected with the *Dialog Designer* and singularly configured for each theme present in the view, drive the user in the insertion, modify and consultation of the data relative to the various themes (see Fig. 4, Fig. 5).

The login to the system happens through user name and password. A punctual control of the functions realized has allowed to provide two types of user-profile: the first one is the administrator user, that may use the system in complete way. The other profile is divided in more typologies, that can be managed according to the level of interaction with the data allowed to the user. In some cases is allowed the modify of information, in other cases it will be possible only the navigation through the various consultation itineraries.

To mention only the more significant features (*cf.* [10],[11]), the functions of ARKIS may be summed up as follows:

- to guarantee on-screen outlining of areas to which associate specific themes; these are automatically linked to the referred records with the descriptive information;
- to drive the user in inserting new descriptive data in *user friendly* dialog windows, presenting for specific information drop down menus;
- to automatically code each new entity, ensuring links between the various scales and the automatic updating of the RDBMS;
- to activate one or more themes, with consequent overlay operations;

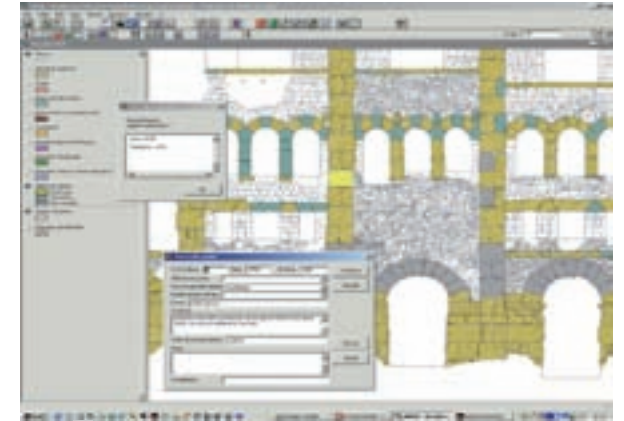


Fig. 6. ARKIS. Roman Theatre at Aosta. A consultation data phase (dialog window) on a selected ashlar; in the small box are calculated area and perimeter [P. Salonia et al., *Research Agreement with Sopr. BB.CC.AA of Valle d'Aosta Autonomous Region, CNR ITABC*]

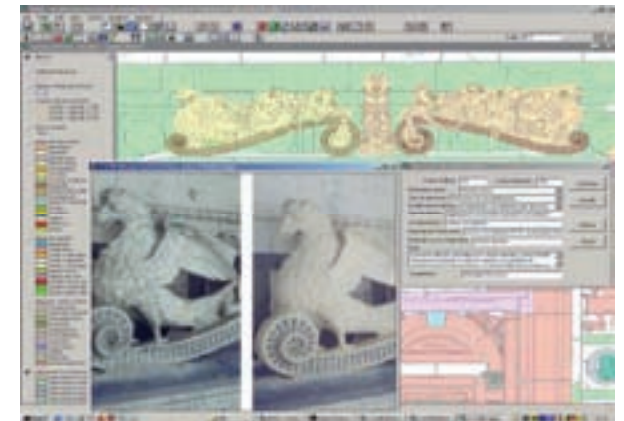


Fig. 7. ARKIS. Certosa at Pavia. The information about materials used in the restoration intervention are in the dialog window, in the images we can see ante et post operam [P. Salonia et al., *case history for G. Battaglia specialization, CNR ITABC 2004-2005*]

- to open as many attribute/data tables as there are active themes and defined overlays (this allows the description information referring to each single theme to be merged and cross-referenced in a single display);
- to perform query operations and interactive queries with highlighting of the geometric element in the graphic representation;
- to calculate areas, perimeters and percentages in zones affected by the various pathologies discovered (see Fig. 6);
- to call up the photographic image of the detail investigated and/or the rendering of geometric surveys with the relative lists of coordinate points (see Fig. 7, Fig. 8);
- any other interactive analysis operation.

For the purpose of testing the System developed, experiments were conducted using several study cases considered to be sufficiently representative of the object analysed and to be essential examples for validating the theoretical and methodological approach.

The System is user friendly and can be used as a support and guiding operating tool by various different bodies, in particular the Superintendencies. However, it is not enough just to be an operating tool, considering the huge potential possessed by the System. In this connection it may be said that ARKIS, insofar as it forms the central engine driving a project for knowledge management and for this very reason resident on the desktop of the individual user, must necessarily be addressed to a specific 'nomadic' use (to continue with the metaphor): in other words, it must be able to initiate a process of knowledge navigation. This entails seeking the added value contained both in the transfer of information organized by the individual user and in its distribution insofar as it is accessible in remote mode, thereby triggering a multiplying effect regarding the intrinsic meaning of the single information items. It can thus be shared by several users in a network in which planning, comparison, discussion and knowledge are guaranteed.

It was on these conceptual assumptions in the framework of an innovative view of conservation in which the possibility of accessing relevant information plays a fundamental role that the ARKIS - NET Project was based.

4 - Sharing knowledge over the Web

4.1. ARKIS – NET: methodological and technological aspects

A segment of the research is now focused on the **ARKIS–NET** Project, an evolution of ARKIS. It provides the foundation for disseminating high-end heterogeneous data, organised and represented in **GIS** form, and mapping services via Internet. This project enables users to

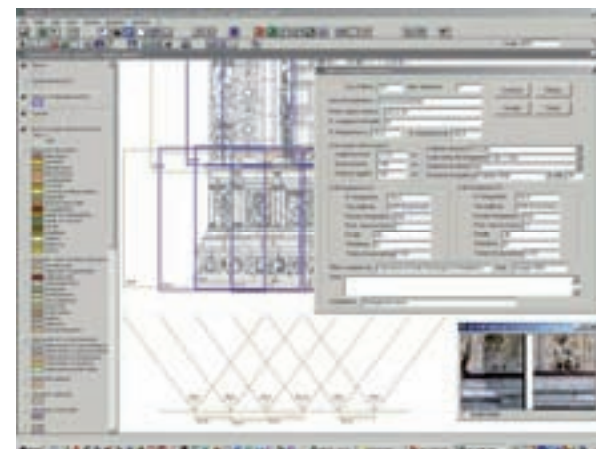


Fig. 8. ARKIS. Certosa at Pavia. The dialog window with photogrammetric survey data [P. Salonia et al., case history for G. Battaglia specialization, CNR ITABC 2004-2005]

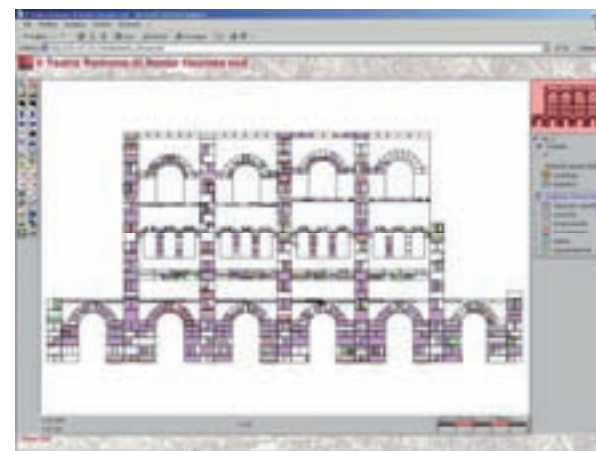


Fig. 9. ARKIS-NET: the access to the consultation of the data. Roman Theatre in Aosta, south facade [P. Salonia et al., Research Agreement with Sopr. BB.CC.AA of Valle d'Aosta Autonomous Region, CNR ITABC]

integrate local data sources with Internet data sources for display, query, and analysis in an easy-to-use Web browser.

ARKIS-NET is based on the ArcIMS software package, the latest ESRI product aimed at the exploitation and distribution of GIS environments. It consists of a new generation of Internet Map Server (IMS), with functions orientated above all towards an open scalable architecture (*cf.* [12]).

There is a Client module and a Server module: the Client typically requests information from the Server, which processes the query and then sends the information back to the Client. The Server technology used by this application is part of a multitasking architecture, that is, the management of the flow of queries received from the various Clients and organized according to different, simultaneously active, services (MapServer) monitored in such a way as to route the queries to the appropriate Spatial Server (Image server, Feature server, Query server and/or Extract server).

The Spatial Server interacts with the WEB Server through the Application Server and its Connectors and sends the response to its Clients.

Several queries may simultaneously be handled by the same Spatial Server, or else multiple queries of each Spatial Server or again one or more Spatial Servers and queries handled simultaneously on more than one machine. This means that clients that are not only powerful but also “intelligent”: the response will be elaborated by the appropriate Server (designed to handle this type of request) and sent back to the Client in real time.

A MapService is a process that runs on the Spatial Server. It provides instructions to a Spatial Server on how to draw a map when a request is received. The input to a MapService is an ArcXML MapService Configuration File. There are two types of MapServices: Image and Feature. An Image MapService uses the image rendering capabilities of the Spatial Server. When a request is received, a map is generated on the server, and the response is returned as a JPEG, PNG or GIF image. A new map is generated each time a clients requests more information.

A Feature MapService uses the Spatial Server’s feature streaming capabilities to bundle data and sent the request to the client. Because more processing is performed in the Java Applet, requests are sent only when additional data is needed.

One of the most interesting functions of the Feature MapService is extracting or clipping data to create a subset that can be sent back in shapefile format.

The Client may have an HTML Viewer or a Java Viewer: the fundamental difference lies essentially in the fact that HTML technology is very slim, does not require the downloading of addition plug-ins to display the data queries (Java Applet) and does not require computers with

Note 4. It is deemed of interest to provide a brief outline of the present configuration of ARKIS-NET, using as example the data referring to the Roman Theatre of Aosta. It thus becomes possible to examine also the interface used by the client user, making the previously illustrated concepts even more explicit. The page providing access to the consultation of the data referring to the south facade of the Roman Theatre of Aosta (see Fig. 9), configured with a clientside Java, displays in the centre the *frame* containing the view with the representation of the geometric model of the facade and the various layers containing the polygons relative to the information layers related to materials and degradation of the individual ashlar. In the top right of the frame there is the navigator (in this specific case, the representation of the entire south facade) that is updated dynamically according to the zoom of the central frame. Below the navigator the Table of Contents (TOC) is illustrated, with a legend for each topic (layers of graphic objects belonging to the same class: polygons, lines, points) present in the view. On the left side of the frame there are a series of navigation, query and data analysis tools. Multiple actions may be performed inside the page, from the various types of zoom and pan to reach the area of interest, to the activation of one or more themes in the TOC, the querying and extraction of information concerning the *table of attributes* of the topics (see Fig. 10), a feature that is fundamental in a GIS environment, which contains the alphanumeric information related to the graphic objects present in the theme (*features*).

In Fig. 11 it is shown how to use the *Query Builder* tool to seek graphic objects (*Features*) corresponding to certain selection criteria, inside the active theme. In the window a search string is constructed that is based on the fields in the *table of attributes* of the *Physico-chemical degradation* theme (active theme), requesting all the ashlar displaying an *Increase in material*. By clicking on the *Execute* button in the window a list appears of the ashlar corresponding to the query criteria. It is also possible to save one's search in a text file by clicking on the *Save* button in the *Query Builder* window. The polygons of the ashlar extracted are shown in the view.

powerful CPUs; however, it only allows display and querying operations. A Java Viewer, although requiring a comparatively powerful machine for processing and additional plug-ins, nevertheless ensures a high degree of interaction with and analysis of the maps.

The communication between clients and servers uses ArcXML. All the ARKIS-NET web pages have been customized with ArcXML, a GIS extension of standard eXtensible Markup Language (XML).

The ArcXML files look similar to HTML pages. The difference is that HTML describes the page structure for display while ArcXML provides the structure for describing the content.

The access to the ARKIS-NET project happens through the pages of the under construction site www.arkis.it: there is a special section where you can enter the online consultation. The ARKIS-NET contents are the same as ARKIS, which continues to act as the information “generating” engine (*cf.* [13], [14], [15]). The data types available on the ARKIS-NET pages are essentially of the vectorial (shapefiles) and raster (image) types, as well as alphanumeric (database tables) and refer to the case studies so far investigated in the System. The remote user can access geographical information either directly on the national map and by querying the tables, searching by building type, municipality, etc. (see note 4.).

Once the choice of case study has been made, he can call up the page dedicated to it using a set of available tools for *pan* and *zoom* the map extent, *query spatial* and *attribute data*, create a *buffer around feature*, *measure objects* on the map, *merge remote data* with *local data* and *save* the work.

If the user is configured as a privileged Client, that is, if he can navigate using a Java Viewer (fast internet connection and a computer with sufficient processing power), he will be able not only to interact with the map through the tools described above, but also:

- add Map Notes, such as text, graphics or images, to your map and submit them for review to the Expert Team (that will evaluate the Map Notes received);
- make Edit Notes to map spatial and attribute data and submit the edits for review to the Expert Team (that will evaluate the Edits received).

4.2. Virtual Reality metaphor for data handling

Other powerful tools for research data organization related to the field of conservation of cultural assets that are useful for cultural heritage experts are web-based technologies and applications (*cf.* [16]) sites can be used for research organization reference points. Furthermore web-related technologies, like Java-script, Java, Php and others can be integrated to enhance interaction and usability (*cf.* [17], [18]).

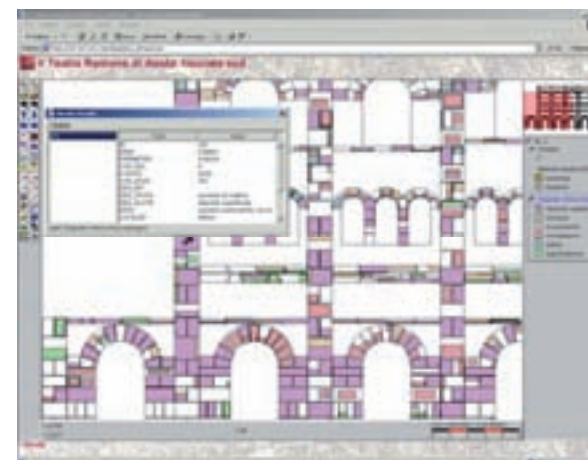


Fig. 10. ARKIS-NET: extraction of information concerning the table of attributes [P. Salonia et al., Research Agreement with Sopr. BB.CC.AA of Valle d'Aosta Autonomous Region, CNR ITABC]



Fig. 11. ARKIS-NET: the Query Builder tool [P. Salonia et al., Research Agreement with Sopr. BB.CC.AA of Valle d'Aosta Autonomous Region, CNR ITABC]

Beside technologies aimed to data organization (*cf.* [19]) we need to consider another branch of computer science useful to make easy researchers workflow and personal understanding: computer graphics. Many tools from computer graphics has been applied in cultural heritage related researches (*cf.* [20], [21], [22]).

Different degrees of visual accuracy, such as photorealistic rendering (*cf.* [23]), can be used in relation with research type. Most used and powerful method is also interactive computer graphics that can be widely used for virtual models and digital-reconstructed buildings exploration (*cf.* [24], [25], [26]).

In the last years some different kind of researches has focused on the way of acquiring, archiving, processing and using data (see note 5.) related to the ancient Roman Theatre at Aosta (see Fig. 12) which is considered a building of historical and architectural interest (see note 6.).

These researches (*cf.* [27], [28]) produced a lot of information about this theatre includes geometric data, images, descriptive information collected by the cultural heritage experts, data generated by previous computations and interesting results on method and models proposed in the field of computer science applied to cultural heritage. Some descriptive and pictorial data have been used to enhance other data to further improve the degree of detail and accuracy of the ancient building description and representation. For example, architectural properties have been extracted by reconstructing 3D models of stones by digital camera acquisition, spectral properties of ancient construction materials have been measured in the laboratory under reconstructive conditions. Also virtual simulations has been developed about hypothesis for lighting design of the remaining archaeological site.

The problem arising has been: how to collect and correlate such an heterogeneous kind of information together and to the subject? The idea explained below is focused on using the 3D model of the building and some imaginary 3D virtual information point.

The implemented interface allows users to navigate in a full three dimensional environment containing a virtual reconstruction of the cultural assets and to retrieve information on it using interaction with the scene geometry. A two-degree level of abstraction approach has been used. The 3D browsable world reconstruction provides a quick interface to collected data as described below. On the other side a GIS based bi-dimensional approach, ARKIS, has been used to get a more detailed description of data and to show relations between it.

A full-interactive, 3D virtual, world has been created by INDACO-POLIMI researchers. The data access metaphor used is based on VRML (Virtual Reality Modeling Language) technology. The VRML scene description capabilities allow users to easily interact with a full featured three dimensional representation of the building. Information can then be associated in a spatial way to most meaningful positions on the 3D model.

Note 5. CNR Strategic Project “Conoscenza per Immagini: un’applicazione ai Beni Culturali” (Resp. Dottt. Laura Moltedo. Project “MURST 5% - Multimedialità.”.

The experimentation was carried out by Maurizio Rossi and Davide Selmo (Politecnico of Milan) and Paolo Salonia and Antonella Negri (CNR ITABC).

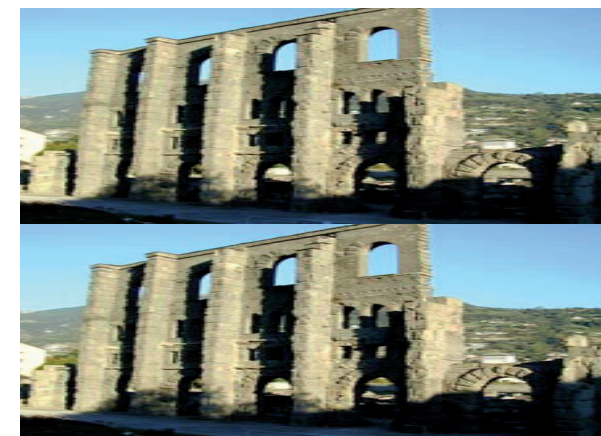


Fig. 12. The Roman Theatre at Aosta. South facade [*Sopra*. BB.CC.AA of Valle d'Aosta Autonomous Region]

Note 6. This is a rare example of covered Roman theatre due to its geographical position that is in a very inhospitable climatic conditions with cold temperatures and significant amounts of moisture for several months during the year. For this reasons, and due to some earthquake, its constituent materials, consisting of travertine ashlars and pudding stones are strongly degraded and only the front and the foundations have survived to our days.

The 3D approach combined with VRML capabilities allows us to handle different kind of data, storing information using miscellaneous data types: 2D raster image, text, multimedia contents, CAD models, full 3D geometry models.

A digital reconstruction of the ancient Roman Theatre in Aosta has been created using all realistic VRML capabilities such lighting effects and surface texturing (see Fig. 13). World navigation has been made easier using built-in virtual-user positions inside the three-dimensional world. This feature also use VRML scene description capabilities. User can then find quickly point-of-interest inside the virtual reconstruction of the asset.

To demonstrate how information related to different field can be collected, a virtual info-point, kiosk, has been created inside the VRML world gathering research result related to the ancient Roman Theatre in Aosta (see Fig. 13).

This kiosk allows the user to get an overview of research results related to the building. Resources connected to the unit, such as images, video multimedia or web-related data are achievable from this location using a link-based approach. The platform-independent scene description language has been used in order to handle link-based connections between scene contents and other web related resources. For example a level-of-detail (LOD) (cf. [29], [30]) model inserted into the three dimensional representation of the world can be reached from the info-point using this approach.

Different kind of external resources can be accessed using the link based approach like movies, other 3D models, LOD representation of geometrical data and web-based services.

A more specific data correlation metaphor is represented by ARKIS, that has been inserted inside the three dimensional scene description so to relate information to the geometrical representation of the building (see Fig. 14).

5 - An innovative and assisted diagnosis system

An other research, a brief illustration of which is deemed to be functional to the theses set out in the present article, is a certainly interesting experience from both the standpoint of the methods used and the richness and multidisciplinary nature of the research group.

This is the Research and Training Project involving Innovative survey and assisted diagnosis systems - SIINDA, developed as part of the National Research Plan – Parnaso Project.

The aim of the Project was to configure innovative methods and techniques for the diagnostic analysis of the monumental heritage, thus involving both theoretical and experimental activities (see note 7.), with the case study being represented by the Roman Theatre of Aosta (see Fig. 15).

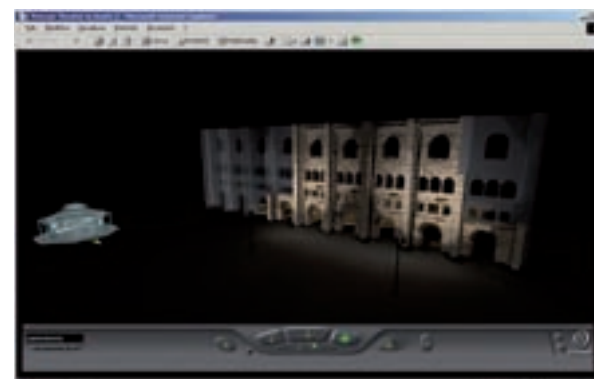


Fig. 13. The resulting virtual model of the sud facade of the Ancient Roman Theatre and the kiosk [M. Rossi et P. Salonia, Politecnico of Milan et CNR ITABC]

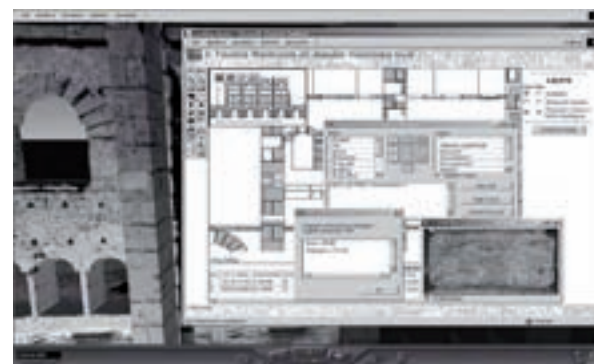


Fig. 14. Access to ARKIS-NET data base from the 3D virtual model [M. Rossi et P. Salonia, Politecnico of Milan et CNR ITABC]

Note 7. The Project was carried out in collaboration by an interdisciplinary group (CNR IAC, ITABC, IEIIT, IMG, Istituto Elettrotecnico Nazionale Galileo Ferraris, DEI PolIMI, Sopr. BB.CC.AA. - Valle d'Aosta Autonomous Region, CM Sistemi, FOART, MENCI SW) gathered together in the ad hoc SIINDA Consortium (President Ing. Romualdo Picco, Director Dott. Laura Molto, Scientific Training Head Arch. Paolo Salonia). The case history was the Roman Theatre at Aosta (see Fig. 15).

The objective was to develop and test an Integrated System of knowledge, monitoring and forecasting, that is a set of techniques, functions and data that can be used for the computer-assisted introduction of different levels of objectivity in the evaluation of a building's state of conservation, the integrated storage of heterogeneous data, the subsequent monitoring phases leading to the build up of "experience" required to plan "programmed conservation" action.

This objective was attained by means of the combined, interactive and, as far as possible, automatic use of several different methods of acquisition, analysis and processing methods, thus making the information accessible through an integrated multi-level and multi-scale ICT system and using colour (and thus the processing of colorimetric data and of the corresponding images) as the principal indicator of the various degradation pathologies (see Fig. 16).



Fig. 16. SIINDA Project – Upper. Mapping homogeneous degradation regions on colorimetric data: extracted edges by segmentation algorithm starting from colored images (algorithm by CNR IAC, interface and data processing by CM Sistemi). Bottom. Projection of the extracted edges on the 3D model and window with decay data. [SIINDA Consortium]

The user interface of the Integrated System was of the non-immersive virtual reality type, the three-dimensional model representing the very metaphor of interactivity.

It follows that the user can adopt this model as a basis for displaying other information projectable onto it in order both to consult data contained in the database and to activate the processing functions to implement on these data (see Fig. 17).

Furthermore, the System was conceived and implemented as a modular structure and the individual modules consist of individual autonomous tools, each with its own specific and highly specialist task to perform. As the final stage in the gathering of the more significant information of importance for evaluative synthesis the automated "assessment form" structure was

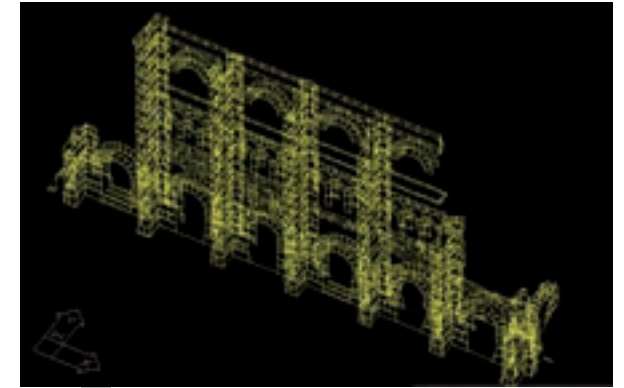


Fig. 15. SIINDA Project – 3D vector reconstruction of photogrammetric survey of the Roman Theatre at Aosta by Fo.A.R.T. [SIINDA Consortium]

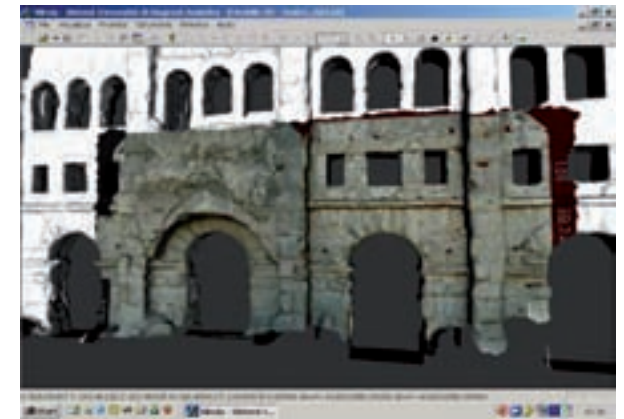


Fig. 17. SIINDA Project – 3D model as a basis for displaying information projectable onto it (here an orthophoto of photogrammetric survey by Fo.A.R.T, interface and data processing by CM Sistemi) [SIINDA Consortium]

developed, linked to the methods used to measure the degradation. This synthesis tool is used to gather heterogeneous information, including that deriving from laboratory analyses, and offers the possibility of linking them up via the definition of a framework that synthesizes the respective influences on the state of conservation as a function also of the quality of the environment-monument system. The form may be updated and adapted as required by the user to the type of monument investigated and guarantees a method for a suitable assessment of the general interpretation of the problems involved in the monument's conservation.

One of the main peculiarities of the present version of the System is its adaptability to technological development in the sense that each module and the ways the various modules can be combined are the result of an "open" design that allows data to be managed – from acquisition to processing and through to integration - whatever the technological level used.

It may thus be claimed that the Integrated System, precisely by virtue of its main characteristics, whereby it may be defined as a tool that assists geometric and colourimetric data acquisition, that indicates exportable methodologies, that represents, displays and texturizes, that processes images to identify degradation, that synthesizes heterogeneous data in support of diagnosis, is on the whole, already in its current prototype version, ready to be transferred into an operative environment, albeit at different experimental levels.

6 - Conclusion

At the end of these in-depth studies, it is possible to draw a brief conclusion that, by combining the different topics treated as though they were a two-fold aspect of the same reality, makes a synthetic, albeit partial, contribution to the debate on which the thematic school is focused. The aim is to place at the centre of the same debate a moment of pause and reflection to ask where we are going, how we are getting there and why [31].

What we have spoken about here is essentially the need to identify, and help train, new professional figures that are capable of planning new projects and of acting innovatively in a sector that, with its century old tradition of "doing conservation", now needs a new operative approach in which there is full awareness of how the enabling technologies must be considered solely as a means of replacing the previously used tools.

The specific problems of conservation, seeing that they involve a range of different skills in order to understand the mechanisms and dynamics of the phenomena of material and structural degradation, in order to define the existing interactions with the surrounding physical environment, and in order to trace out consistent logical frameworks of action hierarchies, means that the design phase of the entire conservation process must constantly be given priority.

Within this, in order to further emphasize what has been illustrated so far, it is the clarity of the objective, whether general or particular, to be attained that becomes of primary importance.

At a second moment, although in terms consistent with the objective itself, comes the identification and choice of the technologically most suitable tool to use, study and test.

References

- [1.] L. Moltedo, R. Picco et P. Salonia, “La presenza delle Tecnologie dell'Informazione nella ricerca sui Beni Culturali: risultati di una indagine”, *Archeologia e Calcolatori*, Firenze 2000, vol. 11
- [2.] L. Menci, “*StereoSpace: an idea for photogrammetric data collection*”, [in] *Proceedings XIX, ISPRS Congress, Amsterdam 2000*
- [3.] K. Kraus, “*Photogrammetry*“, Dummler, Bonn 1997
- [4.] L. Menci, F. Ceccaroni et P. Salonia, “*The stereoscopic exploration of 3D-models as instrument of knowledge, documentation and measurement for mural painting*” [in] *Proceedings Symposium ICCROM on Graphic Documentation Systems in Conservation of Mural Paintings GraDoc, Roma 1999*
- [5.] P. Salonia , “*Quick photogrammetric systems applied to documentation of Cultural Heritage: the example of Aosta roman city wall*”, [in] *Proceedings CIPA XX, Torino 2005*
- [6.] P. Salonia et al., “*Il progetto Appia Antica: sperimentazione di sistemi innovativi di fotogrammetria 3D*, [in] *Proceedings Congress eArcom04, Ancona 2004*
- [7.] P. Salonia et A. Negri, “*Strumenti e metodologie per la conoscenza del patrimonio edilizio storico: un sistema informativo*”, [in] *Proceeding 1° International Congress on Science and Technology for the safeguard of cultural heritage in Mediterranean Basin, Catania, Siracusa 1995*
- [8.] B.W. Hickin, D.J. Maguire et A. Strachan, “*Introduction to Gis: the Arc/INFO Method*”, Midlands Regional Research Laboratory, University of Leicester. 1991
- [9.] D.J. Maguire, M.F. Goodchild et D.W. Rhind, “*Geographical Information System. Principles and Applications*”, Longman Group UK Limited, John Wiley & Sons, Inc., New York 1991
- [10.] P. Salonia, “*Tecnologie informatiche per la gestione delle conoscenze nella conservazione del costruito storico*”, *Archeologia e Calcolatori*, Firenze 2000, vol. 11
- [11.] P. Salonia et A. Negri, “*ARKIS An Information System as a Tool for Analysis and Representation of Heterogeneous Data on an Architectural Scale*”, [in] *Proc. of 8-th WSCG Conf. '2000, Plzen 2000*
- [12.] C. Harder, “*Serving Maps on the Internet*”, ESRI Press, U.S. 1998
- [13.] P. Salonia et A. Negri, “*Dissemination of heterogeneous informations in the recovery of historical buildings: ARKIS – NET*”, [in] *Proceedings II International Congress on Science and Technology for the safeguard of cultural heritage in Mediterranean Basin, Alcalá de Henares 2001*
- [14.] P. Salonia et Negri, “*Cultural Heritage emergency: GIS- based tools for assessing and deciding preservation and management*”, [in] *Proceedings XXIII Annual ESRI User Conference, San Diego 2003*

- [15.] P. Salonia et Negri, "ARKIS-NET: un Web-GIS per il progetto di conservazione assistito", *Archeologia e Calcolatori*, Firenze 2005, vol. 16
- [16.] J. Marshall, "Developing Internet-Based GIS Applications", [in] Proceedings XX Annual ESRI User Conference, 2000
- [17.] R.M. Roher et E. Swing, "Web-based information visualization", *Computer Graphics and Applications*, July/August 1997, vol. 17
- [18.] D. Marini et M. Rossi, "Cultural Heritage Data Base Interface, a case study: The Aosta Roman Theatre", [in] Proceedings 4rd International Conference on Cultural Heritage Networks Hypermedia & Medici Framework, Milano 1999
- [19.] M. Gaiani et C. Alessandri, "The atrium of St. Mary Abbey in Pomposa: a hypermedial 3-D network database", [in] Short papers and demo proceedings Eurographics'99 – Eurographics Association, Milano 1999
- [20.] D. Marini et al., "Virtual Reality And Web Tools To Convey The Visual Information Of Ancient Monuments", *Computer Networks and ISDN Systems*, 1997, vol. 29
- [21.] E.L. Vote et al., "ARCHAVE: A Virtual Environment for Archaeological Research", [in] Proceedings IEEE Visualization 2000, Salt Lake City 2000
- [22.] N. Bates-Brkljac, "Issues In Developing A Prototype For A virtual Archive And Library For Cathedrals – VirtuAL project", [in] Proceedings EVA 2002, London 2002
- [23.] M. Rossi, D. Marini et A. Rizzi, "Photorealistic rendering over the Internet for restoration support of ancient buildings", [in] Proceedings SPIE Electronic Imaging 2001, San Josè 2001, vol. 4311
- [24.] M. Rossi, "Virtual Reality and Photorealistic Representation of Ancient Monuments", [in] Proceedings Eurographics 99 tutorial T5, Milano 1999
- [25.] S. Doyle, M. Dodge et A. Smith, "The potential of Web-based mapping and virtual reality technologies for modelling urban environments", *Computers, Environment and Urban Systems*, 1998, Vol. 22, n° 2
- [26.] M. Gaiani et A.C. Addison, "'Virtualized' Architectural Heritage - New Tools and Techniques for Capturing Built History", *IEEE multimedia*, aprile-giugno 2000, vol. 7, n° 2
- [27.] L. Moltedo, "Conoscenza per Immagini '97", Il Rostro, Milano 1997
- [28.] M. Rossi et P. Salonia, "Comunicazione multimediale per i beni culturali", Addison Wesley, Milano 2003
- [29.] L. De Florian et al., "Level-of-Detail in Surface and Volume Modeling", [in] Proceedings Eurographics 99 tutorial, Milano 1999
- [30.] S. Flick et V.Coors, "Integrating levels of detail in a Web-based 3D-GIS", [in] Proceedings 6th International Symposium on Advances in Geographic Information Systems (ACM GIS'98), 1998
- [31.] M. Rossi et P. Salonia, "Multimedia Information @Design for Cultural Heritage - MIDECH '05", Aracne Ed., Roma 2005

On basic perspective system of illusionistic-architectural vault paintings

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Noncolinear perspective, illusion, geometry, architecture

J.5 - ARTS AND HUMANITIES

The authoress is working on the systemizing of the illusionistic-architectural paintings in Poland, by geometric criteria. From the geometric point of view, the most interesting group are vault paintings called quadratures. Thanks to their extensive geometric knowledge as well as the knowledge of the future observer's habits, the quadrature painters created complex perspective systems. The literature on quadratures provides restricted knowledge on the systems. The problem is even greater, due to the fact that the vault paintings (curved surfaces) are noncolinear perspectives.

Both facts are of essential importance for creation of paintings, their preservation and perception as well as attempt to systemize them.

To illustrate the basic notions related to perspective systems and noncolinearity of pictures, copies of the proprietary program „Quadrature” screens have been presented in this paper.

1 - Introduction

Architectural structure partitions have represented background for paintings on various subjects and interesting composition solutions for centuries. Numerous are not far from the transpositions that we know from board (case) pictures. The difference characteristic for the architectural structures was the tendency to replace the real elements and architectural details with their illusionistic pictures. We will call such a architectural tendency – quadraturism. The triumph of quadraturism occurred in Italy during the Renaissance period and throughout Europe – in the Baroque. This was when the illusionistic-architectural paintings were created, whose application in an architectural interior not only was to replace the real architectural elements, but most of all, to replace a real architectural space. In the authoress' opinion, the top achievement of quadraturism were vault paintings that made the observers yield to the illusion that the interiors they were in were by whole floors higher than the real ones. We shall call such paintings vault quadratures and the basic perspective systems applied therein shall be the subject of this paper (see note 1 and [2]).



Note 1. In the literature related to the illusionistic-architectural paintings, we may find various definitions of quadraturisms and quadratures, therefore the authoress found it necessary to provide her own definition. The definition of the vault quadrature suggested by her is closest to the definition proposed by I. Sjöström the paper *Quadratura...*[1] and has been made under her influence.

Fig. 1. An example of quadrature. Fresco dated ca 1765-1770, author unknown. The vault in the aisle of the church in Łęczycza Poland. [aut. A.Žaba, 2005].

The purpose of the paper is to define the basic vault quadratures related to the geometric specific character of vault quadratures. The article will present only two basic perspective systems.

2 - Basic terms related to perspective.

Central projection – geometric method of constructing pictures called perspectives. The perspectives are close to the pictures perceived by human eye. The basic elements of the projection include – see fig.2.

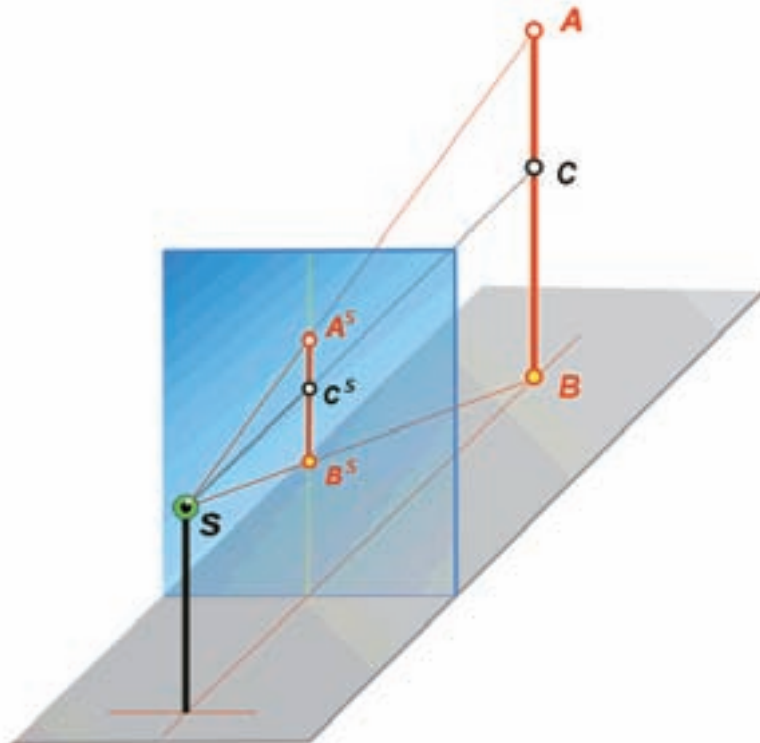


Fig. 2. Selected elements of central projection.

The basic elements of the projection include:

centre of projection S – point where the vision radii converge, identified with the structural observation point, also with the observer's eye,

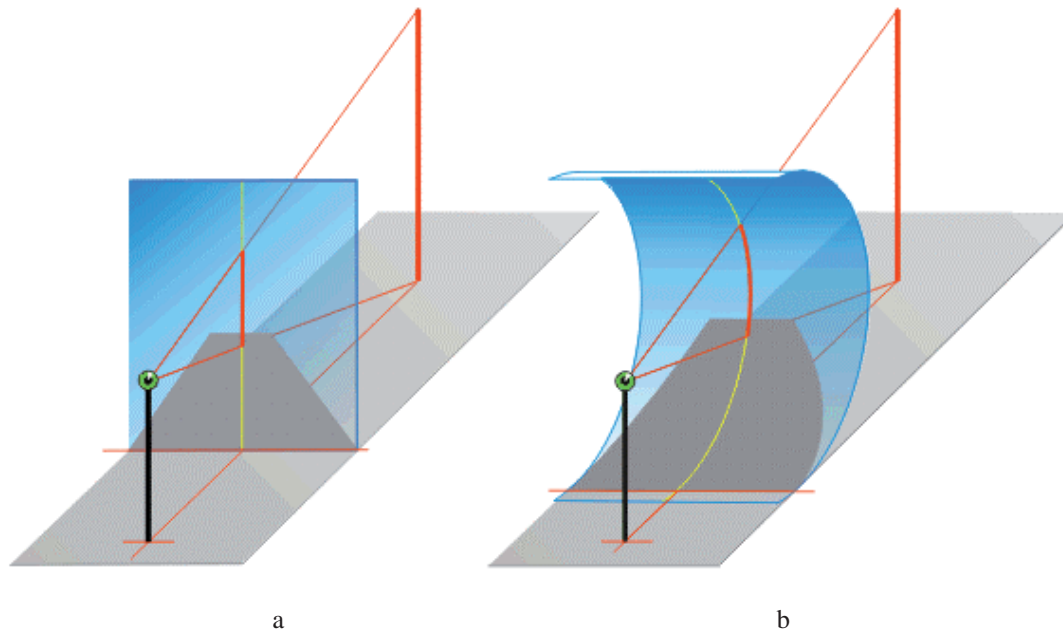
background – plane or surface the object's perspective is constructed on,

object AB – existing (real) object or designed the perspective whereof we construct against the background,

vision radius – the straight line that connects the projection centre with S a point in the object A and its perspective against the background A^S

Colinear (linear) perspective – picture wherein the straight-line sections in its picture correspond to all the straight-line sections of the object; it refers to the perspectives on planes.

Noncolinear perspective – picture wherein curve sections (in general case) correspond to the straight-line sections of the object; it refers to the perspectives on curved planes (see fig. 3 and [3])



3 - Assumptions

Due to the untypical and complex nature of the problem of perspective systems and the need to illustrate the text with demonstrative drawings, a simplified model of an architectural object was assumed.

Model is a rectangular prism with orthogonal projection, open from the top. The lateral walls of the model were divided into two equal parts with a horizontal plane. The lower part is formed by the grey rectangles with vertical white strips. The upper part, however, was designed as lattice, consisting of vertical strips and closed with a horizontal strip from the top. The vertical elements of the upper part represent the extension of the lower vertical white strips. Let us assume that the model was made in a complete architectural object's scale. The model assumed



Fig. 3. Perspective: (a) - colinear, (b) - noncolinear, (c) - an example of a quadrature perspective in the vault; The Bernardines' Church in Lviv, the Ukraine. Painter: B. Mazurkiewicz, 1738-1740, [aut. A. Žaba, 2006].

replaces the traditional architectural layout (inside of the courtyard) wherein the floor colonnade closed from the top with the beams corresponds to the pillars or pilasters of the ground floor level (fig. 4).

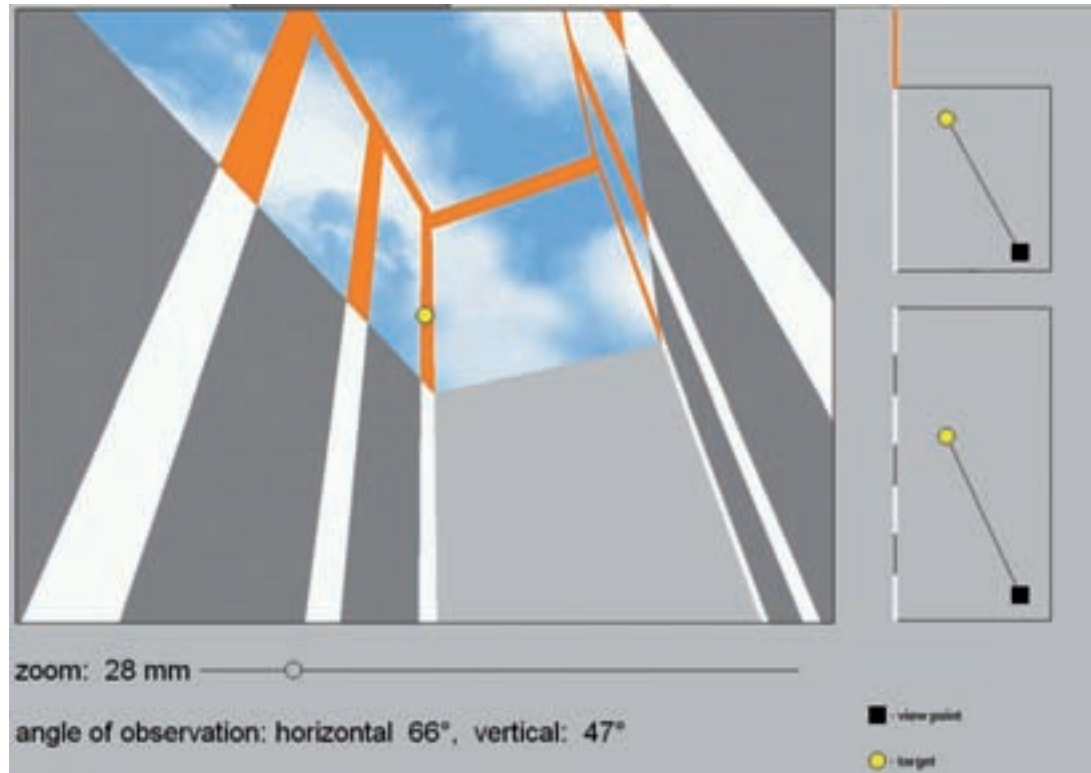
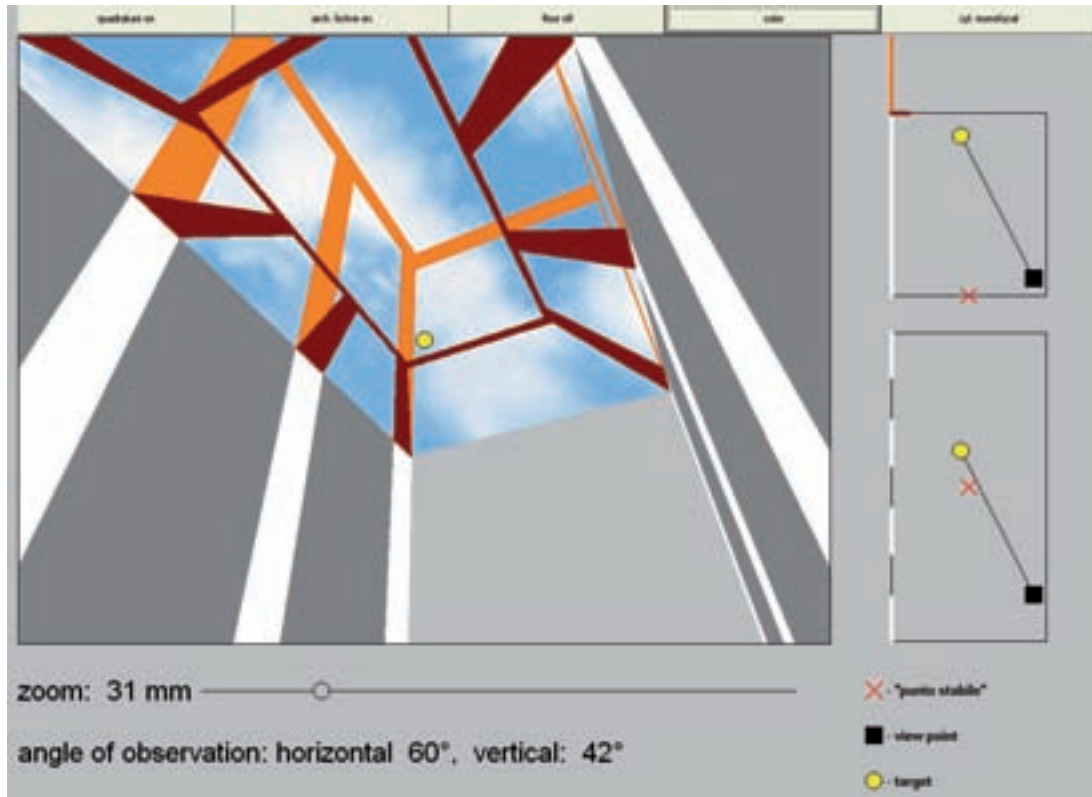


Fig. 4. Perspective of model seen from its centre (see: the location sketch next to the perspective). Copy of the “Quadrature” program screen [aut. H.Gliński, A. Żaba].

4 - Difference between ceiling and vault pictures

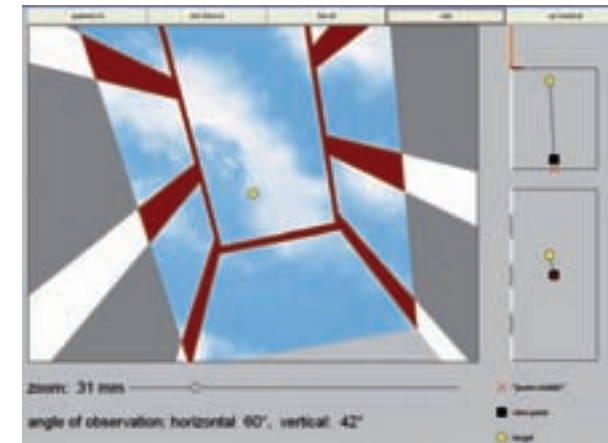
Let us add the transparent horizontal plane to the model accomplished, the plane that separates the ground floor from the first floor. The observer standing in such interior can see the upper floor through the glass ceiling. The ceiling plane will be the background for the upper floor perspective constructed for the assumed location of the structural observation point. In historical structures such point was projected orthogonally on the interior’s floor. Frequently, such point was marked by means of a tile of different colour or shape and called *punto stabile*.

Punto stabile is thus a point where the observer should stand, so that his eye is placed in the very location the perspective in the ceiling has been constructed for. Let us assume then that *punto stabile* is located in the centre of the floor. Let us also assume that the perspective constructed



b

ceiling will be called the quadrature perspective. Due to the fact that the ceiling is made of glass, moving inside the model, the observer not only sees the quadrature perspective, but also the fragments of the model's upper floor. It is only when the observer stands in *punto stabile* that the quadrature perspective totally covers the model's floor elements (fig. 5).

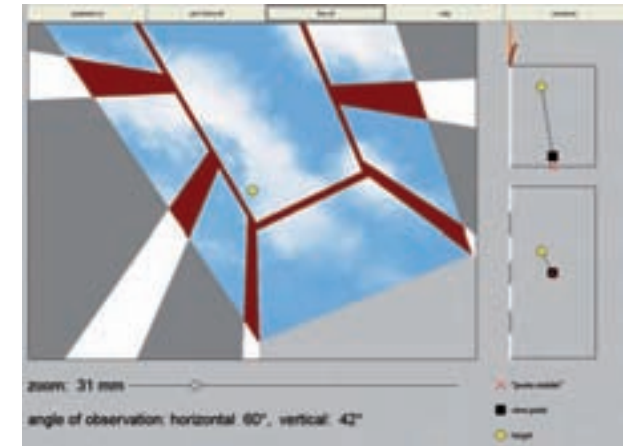
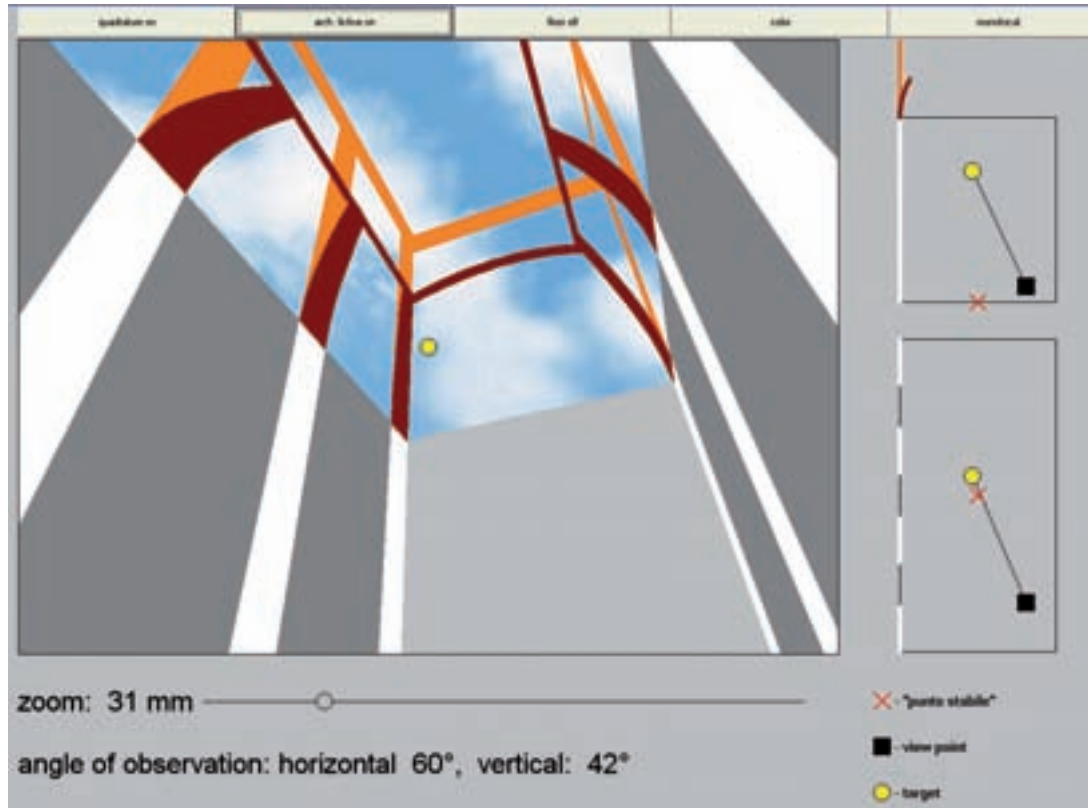


a

Fig. 5. The model's perspective together with the quadrature perspective in the ceiling, when the observer stands in: (a) - *punto stabile*, (b) - other place
Copy of the "Quadrature" program screen [aut. H.Gliński, A, Žaba].

On basic perspective system of illusionistic-architectural vault painting

If the picture's background is a glass barrel vault, i.e. half of the lateral surface of a rotational cylinder, the situation is close to the preceding one (fig.6).



a

b

Fig. 6. The model's perspective together with the quadrature in the vault, when the observer stands in: (a) - punto stabilne, (b) - other place.

Copy of the "Quadrature" program screen [aut. H.Gliński, A. Żaba].

The real architectural structure differs from the assumed model. The most important thing for our considerations is the fact that the upper floor does not exist and the horizontal partition is not transparent. The quadrature perspective on the horizontal partition was a perspective constructed basing o the structure's design. The methods of constructing quadrature perspectives were published in Renaissance and Baroque treatises. The observer standing in the interior sees the quadrature perspective where the high vertical architectural elements „behave” non-typically (fig.7 and 8).

This phenomenon was described by art historians numerously, they wrote that the columns painted on the vaults were swinging, falling down, etc. Such columns would not surprise us were it a cartoon. However this is going on in a church aisle and perhaps the angels and saints painted

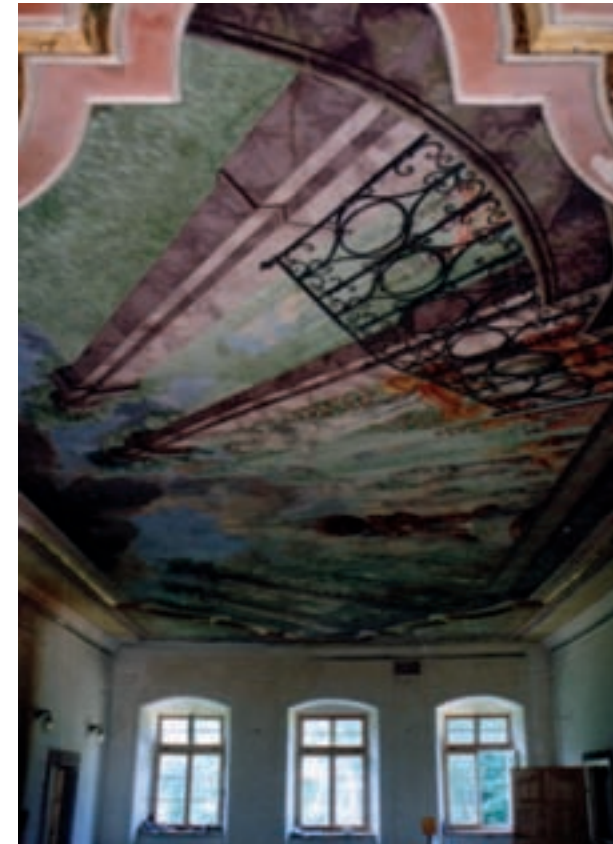


Fig. 7. An example of a quadrature perspective in the ceiling, author unknown. The Palace in Ścinawka, Poland [aut. T. Wiśniewski, 1999].

Fig. 8. An example of a quadrature perspective in the vault. The Jesuits' Church in Brzeg, Poland. Painter: J. Kuben, 1739-1745, [aut. A. Žaba, 1999].

there are the only ones not surprised with the „plastic deformation” of the vertical structural elements (see [6]). The analysis carried out on the pictures was to introduce the reader to the issues related to various perspective systems.

5 - On perspective systems

A perspective system is a number of structural observation points assumed for a particular picture and the method of composing such picture from the parts that are the perspectives or their fragments constructed for such points. We may find information on the perspective systems in papers [1], [4] and [5].

Monofocal system – is a perspective system with one structural observation point. All the perspectives presented before were constructed in the monofocal system. Some vault structure authors (e.g. Andrea Pozzo [7]) presumed that the monofocal system was better than the polyfocal one.

Polyfocal system – is a perspective system with at least two observation points assumed and the picture is composed of perspectives or their fragments constructed for such points.

In case of quadrature perspectives, the introduction of the polyfocal systems was, most of all, aimed at the reduction of the „perpendicular deformations”.

A typical solution was the use of the polyfocal system with four structural observation points that were spaced in the interior as presented in the drawing. The points of convergence of such perpendiculars unify with the observation points in the structural projection (fig. 9 and fig. 10).

Let us go back to the model assumed before, in order watch the effect of the use of the polyfocal system on the quadrature perspective. Next let us construct the quadrature perspective for each structural observation point. A fragment should be selected out of each perspective and connected into one picture. Now let us see the effect of our actions (fig.11).

In the authoress' opinion, the construction of a picture in the polyfocal system does not guarantee any „perpendicular deformations” in the vault quadratures where high architectural elements always appear. We can also see another problem that did not occur in the traditional monofocal system. The beaming in the polyfocal system has been interrupted and the deformation reduction is incomplete. This is probably why other polyfocal solutions were searched for, ones the authoress has not examined yet with the method she applied in the paper.

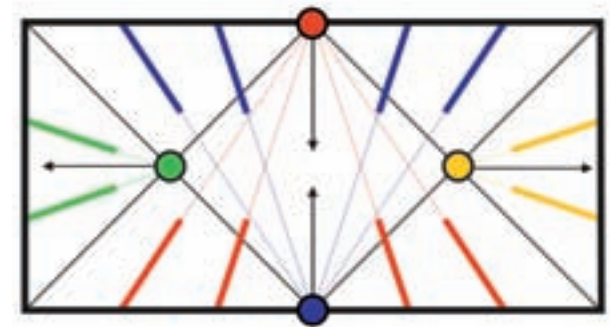


Fig. 9. Location of structural projection points within the most popular polyfocal system.



6 - Conclusion

Upon analysis of the selected example of the polyfocal system, it seems that one may safely assume a thesis on the necessity for search of the perpendicular deformation problem solution that interests us in the combination of a polyfocal perspective system with relevant compositions solution.

In order to prove this thesis, it is necessary to examine other polyfocal systems. The research should refer to the perspectives of interiors, as in case of vault quadratures, the relationship between the lower, real floor perpendiculars with the elements painted on the vault is the main indicator of the picture deformation.

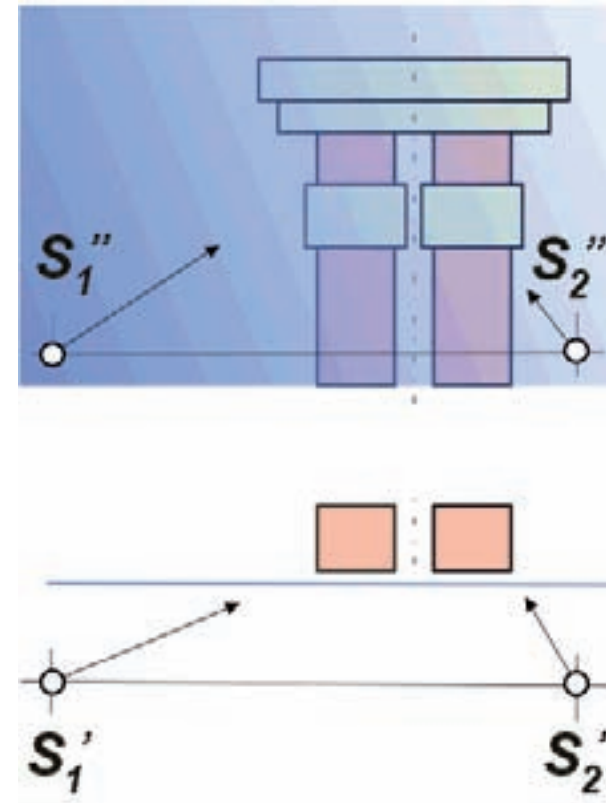


Fig. 10. The structure of a picture in the polyfocal system with two structural observation points and an example. Church in Skępe, Poland. Painter: W. Żebrowski, [aut. A. Żaba, 2005].

On basic perspective system of illusionistic-architectural vault painting

After the experience gained thanks to the possibilities of computer perspective picture creation, the authoress managed to settle that there are solutions where polyfocal perspective systems were used, among the vault structures preserved in Poland.

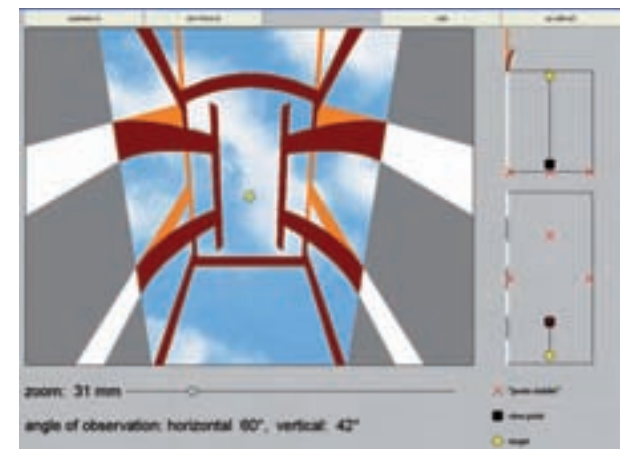
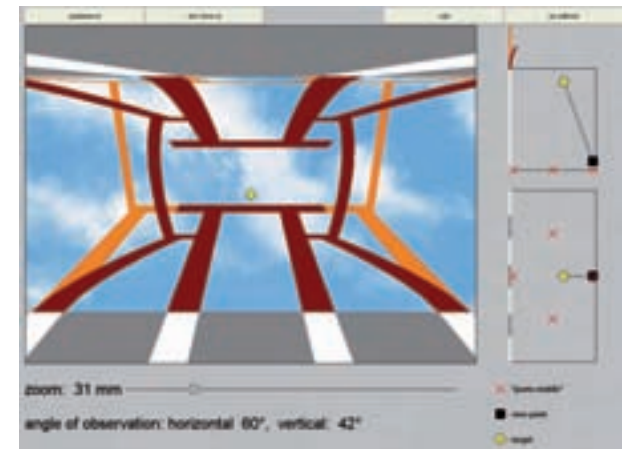
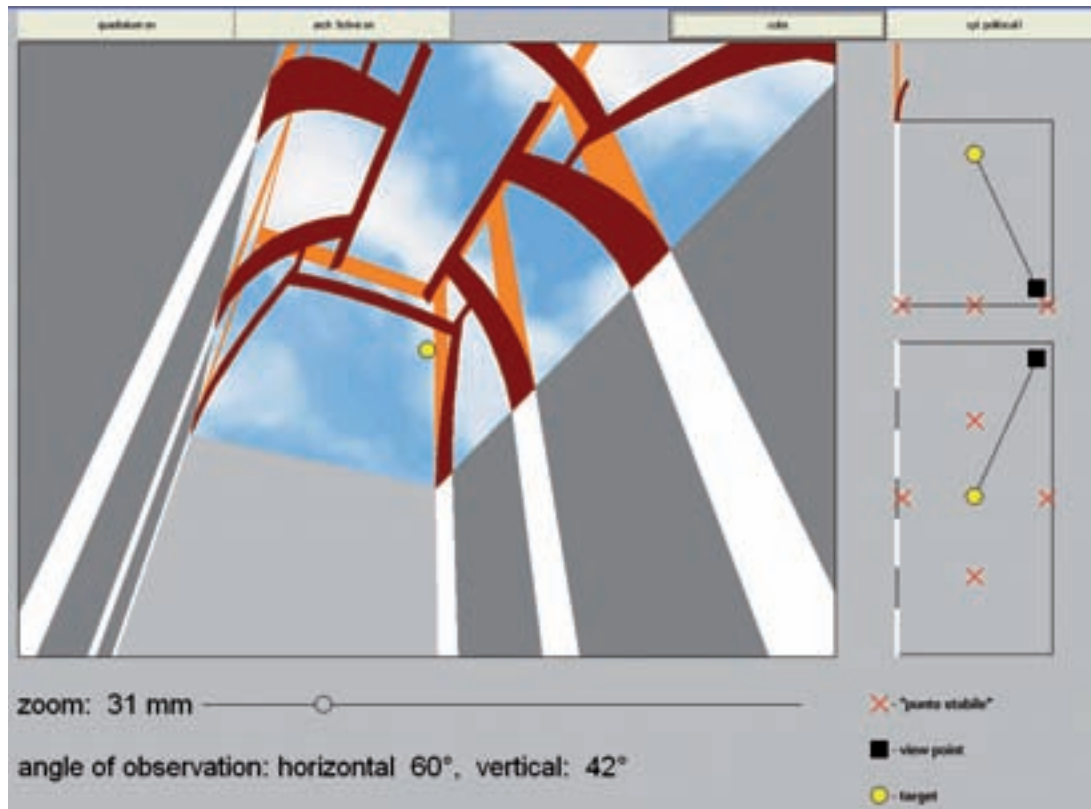


Fig. 11. The model's perspectives together with the vault with a picture constructed in the polyfocal system thereon (a) and (b) - punto stabile, (c) - other place.

Referenc

- [1.] I. Sjöström, *“Quadratura. Studies in Italian Ceiling Painting”*, Almqvist & Wiksell International, Stockholm 1975
- [2.] S. Masserano, *“L’immagine dello spazio celeste: la ‘quadratura’ di Giovanni Antonio Fumiani a San Pantalon(Venezja)”* [in] *Geometrie segrete, L’architettura e le sue ‘immagini’*, Venezia 2002, pp. 87-107
- [3.] G. D’Acunto, *“Rappresentare il mondo immaginabile”*, [in] *Geometrie segrete, L’architettura e le sue ‘immagini’*, Venezia 2002, pp. 22-38
- [4.] D. Folga-Januszewska, *“Wprowadzenie do zagadnień przedpozzowskiej perspektywy iluzjonistycznych malowideł ściennych”*, *Biuletyn Historii Sztuki*, 1981, n°2, pp. 203-212
- [5.] A. L. Podgornyj, *“Plafonnaja perspektiwa”*, LDSiA USSR, Kiev 1959
- [6.] A. Żaba, *“Zdumiewająca przestrzeń pojednania człowieka z Bogiem”*, [in] *“Magia iluzji. Dzieło Jana Kubena”*, Kolporter Opole 2000, pp. 83-109
- [7.] A. Pozzo, *“Perspectiva pictorum et architectorum”*, Augsburg 1719

Reconstitution numérique de l'aménagement historique de Cracovie

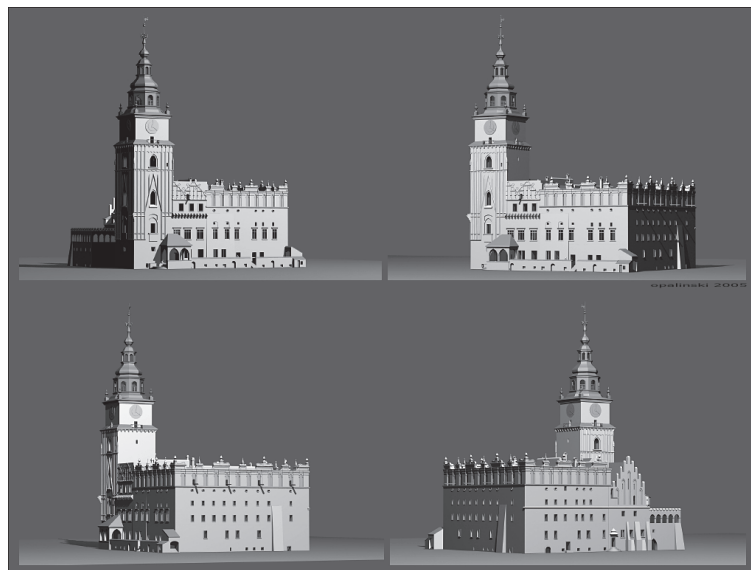
Projet réalisé au Musée Historique de Ville de Cracovie

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En 2005 au Musée Historique de la Ville de Cracovie un vaste projet de recherche a été commencé, dont l'objectif est la reconstitution de l'aménagement ancien de Cracovie, tenant compte des questions de l'urbanisme et de l'architecture de la ville.

Dans ce but, une équipe de spécialistes en plusieurs matières s'est constituée, entreprenant un travail interdisciplinaire commun.

Dans le cadre de cette élaboration, on a recours à des sources de différentes sortes, ainsi qu'à l'expérience inestimable des auteurs. Parmi ces sources, une importance particulière revient à l'iconographie ancienne, composée d'ouvrages exécutés avec plusieurs techniques artistiques et techniques de reproduction, de la gravure, par le dessin, la peinture, jusqu'à la photographie pratiquée depuis le XIX^e siècle.

La collection iconographique constitue l'une des collections principales du Musée Historique. C'est elle justement qui est devenue l'inspiration essentielle et le point de départ du projet. L'iconographie ancienne constitue le support fondamental afin de réaliser ce projet. L'utilité de cette source ne saurait être surestimée.

Le projet vise la reconstitution de deux espaces urbains, différents en ce qui concerne l'étendue, le moment historique visé et le degré de l'élaboration du détail exigé. Le résultat final du projet sera l'exécution de deux maquettes plastiques urbanistico-architectoniques, ainsi que de cinq modèles détaillés des édifices choisis.

Comme effet de cette collaboration, une „Nouvelle iconographie” de la ville ancienne est en cours de constitution; elle est d'une valeur remarquable. Le projet jouit d'une reconnaissance croissante et sera continué dans l'avenir, contribuant de façon considérable à la conservation du patrimoine national, ainsi qu'à l'éducation dans ce domaine.

1 – Introduction

Il est réalisé actuellement au Musée Historique de la Ville Cracovie un projet visant à la reconstitution numérique de l'aménagement ancien de la ville. Jusqu'à aujourd'hui, Cracovie a gardé une disposition spatiale unique en Europe, constituée à l'époque du Moyen Age résultant de la loi de Magdebourg (1257). Les villes de Kleparz et Kazimierz, fondées à proximité de Cracovie au XIV^e siècle, ainsi que les complexes suburbains, constituaient au XVII^e siècle un complexe compact, formant avec la ville de Cracovie un ensemble cohérent du point de vue fonctionnel.

En outre, la partie la plus ancienne de Cracovie, ainsi que les complexes voisins constituant à présent certains quartiers de la ville, ont conservé un nombre considérable de bâtiments et de dispositions spatiales entières appartenant à l'aménagement ancien.

C'est pourquoi Cracovie, ville figurant sur la liste du patrimoine mondial de l'UNESCO, se présente comme un objet intéressant et même idéal pour un projet de reconstitution de l'aménagement historique, en tenant compte des fonctions anciennes de l'organisme urbain.

L'idée de ce projet a vu le jour au début de 2004, tout d'abord comme intention de créer une maquette plastique. Après de nombreuses consultations de spécialistes en histoire de l'architecture et de l'urbanisme, histoire, histoire des beaux-arts et histoire économique, ainsi que d'architectes, l'idée a commencé à évoluer pour aboutir enfin à sa forme réalisée actuellement (voir la note 1). A présent, un modèle numérique de l'aménagement est en préparation (fig. Il fournira le matériel pour la future exécution de la maquette plastique mentionnée, en vue d'une exposition à l'occasion du 750^e anniversaire de la fondation de la ville ("Cracovie – ville européenne de la loi de Magdebourg 1257-1791"), préparée pour le mois de juin 2007, et après, d'une exposition permanente. Il a été prévu également, dans le cadre de cette exposition, une présentation sous forme d'un film et d'un programme interactif.

Enfin, une équipe interdisciplinaire s'est constituée à Cracovie, comptant quelques dizaines de spécialistes participant au projet. Il nous faut souligner que c'est le seul projet d'une telle grandeur dans le cadre polonais, et aussi le seul dont nous avons la connaissance dans un cadre plus élargi.

Plus de vingt personnes engagées comme consultants participent au projet: architectes, historiens de l'architecture, historiens des beaux-arts et historiens spécialisés dans les domaines de l'histoire économique, l'archivistique, la restauration des édifices anciens, et aussi archéologues expérimentés dans le travail sur le terrain. Un rôle important dans cette équipe incombe au groupe d'architectes à qui l'on a confié la tâche de l'élaboration graphique, c'est-à-dire de la préparation des modèles numériques des édifices. J'ai l'honneur de diriger ce groupe en tant que son coordinateur.

Note 1. Les échanges avec UMR CNRS/MCC 694 MAP, représentée par Iwona Dudek, docteur en architecture, ont joué un rôle important dans ces consultations.



Fig. L'Hôtel de Ville et les Halles aux Draps. Réconstitution numérique. (consultation scientifique: W. Komorowski, A. Sudacka, graphique: P. Opaliński, A. Kwaśniewicz)

Cracovie, ancienne capitale de la Pologne, a connu dans son évolution plusieurs étapes intéressantes. C'est pourquoi au commencement de l'élaboration du projet différentes propositions ont été considérées, concernant l'époque visée dans la reconstitution. Il a été envisagé entre autres une reconstitution de la Cracovie de la fin du XV^e siècle, lorsque la ville a atteint l'apogée de son développement économique, possédant en même temps, dans l'enceinte des murs, une structure urbaine en damier entièrement formée. Un cuivre de 1603-1605 a inspiré une autre proposition du moment historique à reconstituer (voir la note 1, Fig 1.).

Finalement, il a été décidé – prenant en considération les arguments cités et afin d'accorder les points de vue différents – une reconstitution de la ville et de l'agglomération voisine au point culminant de son développement historique, première moitié du XVII^e siècle, juste avant la chute soudaine de l'importance de Cracovie et le ralentissement de son développement urbain et architectonique, commencés en 1655 par l'incursion suédoise nommée “déluge”. A cette époque-là, Cracovie conservait encore le caractère médiéval de son aménagement, tout en remplissant déjà les fonctions d'une ville moderne.

Le projet de reconstitution sous forme d'un modèle numérique comprend en plus l'aménagement de la Grand-Place de Cracovie, selon le projet de Dominik Pucek de 1787 (voir la note 2, Fig. 2.).

Présentement, les travaux en question sont bien avancés.

2 – Reconstitution du complexe urbain de Cracovie vers 1650

La reconstitution de l'aménagement historique de la ville concerne, sur le terrain, une superficie de 2 000 kilomètres carrés et compte environ 2000 édifices. En plus, il est nécessaire de prendre en considération la configuration verticale, le réseau routier, les rapports hydrographiques, l'étendue des cultures, les espaces verts variés.

Compte tenu de la dimension de la présentation du détail, on a adopté l'échelle de reconstitution conforme au modèle 1:1000.

Une telle échelle permet de prendre en considération la forme des édifices: plan, étages, divisions horizontales et verticales, embrasures des fenêtres et des portes sans les détails tels que encadrements ou portails. Dans le cas des édifices d'une plus grande importance, comme par exemple le château royal, les édifices sacrés ou conventuels, on prend en compte des détails tels que galeries, colonnes et surtout dômes couronnant les tours. Ces derniers exigent un soin particulier parce que, dans la majorité des cas, ils sont entièrement reconstitués.

A Cracovie, nous sommes confrontés à un cas singulier du fonctionnement de la ville qui, dans l'enceinte de ses murs anciens, a gardé quasiment intacte la disposition des rues et des blocs de

Note 1. La vue la plus parfaite de Cracovie provenant des temps modernes, comprise dans l'oeuvre de Georg Braun et Franz Hogenberg „Civitates Orbis Terrarum”, éditée à Cologne en 1617. Gravée à partir des dessins exécutés sur le vif entre 1603 et 1605. Le cuivre d'un auteur anonyme a servi de base pour des répétitions nombreuses, dont la meilleure et la plus connue est le cuivre de Mateusz Merian de 1617, souvent confondu avec l'original, exécuté sans que l'auteur ait connu la ville dans sa réalité. L'oeuvre créée par l'auteur connaissant parfaitement les réalités de la ville, constitue un véritable trésor d'informations sur la Cracovie de l'époque, et peut être analysée de façon globale. Dans la perspective de notre recherche, son importance résulte de la crédibilité de l'information transmise sur la forme de l'aménagement urbain et ses détails. C'est en même temps l'une des plus anciennes représentations créées d'après nature, et la première aussi fidèle au détail. Ce qu'il faut souligner, c'est la grande valeur artistique de cette gravure.

Note 2. En 1787, une mesure géodésique fut effectuée par le géomètre municipal Dominik Pucek, connue sous le nom de „plan de Dominik Pucek”. Celui-ci embrasse le quadrilatère de l'aménagement entourant le Marché et les édifices se trouvant sur la place: l'Hôtel de ville, les Halles aux Draps avec l'aménagement commercial aujourd'hui disparu, les églises qui y sont situées, et les installations municipales de la Grande Balance et la Petite Balance (édifices destinés à effectuer les mesures du poids des marchandises).



Fig. 1. La vue de Cracovie, du Nord-Ouest, Cologne, 1617.

partir des fragments subsistant de l'attique démontée au début du XIX^e. Les données dont nous disposons afin d'opérer la reconstitution numérique étaient les suivantes: la largeur de la façade, la forme supposée du toit (selon les documents d'archives et l'iconographie postérieure), les éléments subsistant à l'état fragmentaire. Tenant compte des analogies entre les constructions semblables, il a été procédé pour la première fois à la reconstitution d'une attique, qui demeure hypothétique, mais fondée sur toutes les prémisses citées qui, auparavant, n'ont jamais été prises en considération dans une mesure aussi large. Parmi les hypothèses émises jusqu'à nos jours, celle-ci est donc la plus probable (Fig. 4).

C'est à dessein (mais superficiellement à cause de la dimension de cet exposé) que j'ai évoqué l'exemple d'un certain détail de la reconstitution, afin de montrer la minutie de l'objet, mais aussi celle de la démarche des auteurs. Ces derniers sont confrontés à des exemples semblables quasiment à chaque instant de leur travail.

4 – Les édifices les plus importants

Au sein de l'aménagement de la ville, quelques constructions d'une plus grande importance se distinguent. Ils retiennent particulièrement l'attention. Certaines sont devenues l'objet d'élaborations à part. On peut citer l'Hôtel de ville, les Halles aux Draps avec l'aménagement commercial attenant, des églises et complexes conventuels choisis et évidemment le château royal et la cathédrale.

Ces édifices se distinguent habituellement par une meilleure documentation. Ceci permet une élaboration plus détaillée, et la marge d'erreur s'y trouve remarquablement limitée. Le matériel ainsi préparé pourra être utilisé avec succès pour de futures reconstitutions plus minutieuses.

Dans le cadre de ce projet, il est en cours de réalisation des élaborations à un degré élevé de reconstitution du détail, concernant des édifices choisis, importants et caractéristiques de la ville. Chacun d'eux constitue également un sujet séparé en ce qui concerne l'exécution du modèle (voir la note 1).

5 – Les sources de la reconstitution

La reconstitution des édifices, en tant que bâtiments particuliers ou complexes architectoniques, s'effectue en recourant à toutes les sources disponibles. Ces dernières sont analysées minutieusement et comparées par la suite. Il existe des cas où les informations provenant des sources respectives se complètent parfaitement, mais il y en a aussi où elles s'excluent mutuellement (par exemple la description datant de l'époque et la source iconographique). Dans ce genre de cas, une précaution particulière dans l'interprétation est recommandée.

Note 1. Modèles détaillés à élaborer :

1. L'Hôtel de ville à la période gothique (XV^e/XVI^e siècles). Disparu, la tour conservée.
2. L'église de Tous les Saints dans la dernière phase, avant sa démolition complète au XIX^e siècle. Disparue.
3. Le palais „Krzysztofor” dans l'état du XVII^e siècle ; siège de patriciens et de magnats près de la Grand-Place. Conservé, son agrandissement n'a pas affecté sa forme principale.
4. Le complexe de palais et de jardins, siège royal à Łobzów. Intégralement transformé, avec les vestiges des murs et de la fondation originelle.

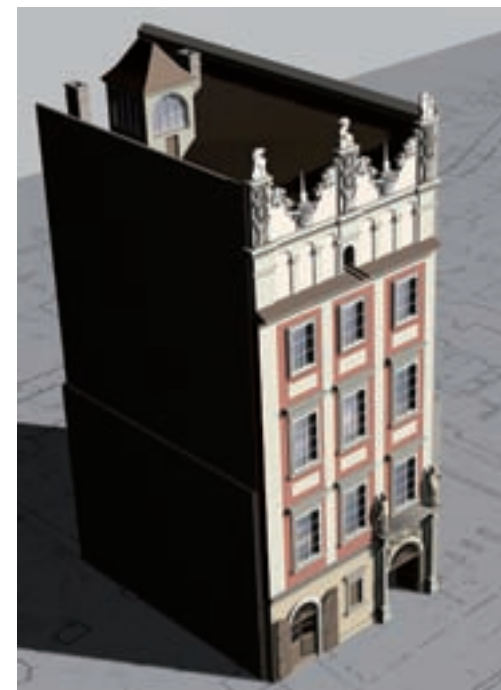


Fig. 4. La reconstitution de la façade avec les détails d'attique de la maison "Bonerowska", (consultation scientifique: W. Komorowski, graphique: P. Opaliński)

5.1. Cartes et plans

Le recours aux cartes, plans et mesures du terrain est fondamental. Comme je l'ai mentionné plus haut, dans l'enceinte des murs, le plan géodésique contemporain est d'une très grande utilité; il reflète le plus exactement les paramètres réels. On y introduit des corrections résultant de l'analyse des plans historiques et des mesures effectuées sur le terrain. Comme nous n'en avons pas toujours la disposition, il est nécessaire parfois de faire appel à d'autres sources.

5.2. Inventaires historiques et contemporains des constructions

Les mesures d'inventaire historiques sont rares et ne concernent qu'un nombre restreint de bâtiments de la ville. Elles datent le plus souvent du XIX^e siècle. En dépit de certaines erreurs qu'elles comportent malheureusement, elles ont une grande valeur du point de vue du projet. Grâce à elles, la reconstruction de l'Hôtel de ville disparu a été possible; cet édifice a été démoli dans la première moitié du XIX^e siècle. Les mesures effectuées à Wawel, au cours des travaux de restauration à la fin du XIX^e et au début du XX^e siècles, sont aussi d'une grande importance. Dans cet ensemble, il faut citer encore les mesures prises à l'occasion de transformations, en cours ou à venir, des édifices historiques de Cracovie. Hélas, ce genre de sources ne concerne que certains des bâtiments et complexes architectoniques.

Les mesures historiques sont complétées par celles que les équipes d'ingénieurs et de restaurateurs effectuent présentement.

5.3. Résultats des recherches archéologiques

Les recherches archéologiques, conduites de manière régulière sur le territoire de Cracovie, permettent d'élucider bien des problèmes, surtout en ce qui concerne la localisation des constructions déjà inexistantes. Les travaux ne sont pas achevés. Ils dureront sans doute longtemps encore. Leur apport à l'état de nos connaissances grandit systématiquement; et notre projet prend en considération l'état le plus récent des recherches dans ce domaine (voir la note 1).

5.4. Iconographie de Cracovie

L'iconographie de la ville a une valeur quasi fondamentale pour le projet. Sans elle, la reconstitution de plusieurs édifices et fragments de l'aménagement aurait été impossible. Je voudrais souligner ici le rôle des collections du Musée Historique de la Ville de Cracovie, propriétaire d'une vaste iconographie de la ville. Celle-ci se compose de gravures et dessins

Note 1. On peut citer à titre d'exemple les résultats inédits, mais fournis au Musée Historique, des recherches archéologiques effectuées sur la Grand-Place en 2004 - 2006 (en 2004 par le Musée Archéologique de Cracovie, directeur: Emil Zaitz; en 2006 par la société Pracownia Archologiczno-Architektoniczna « Niegoda », directeur: dr Cezary Buśko). Ces recherches ont apporté nombre d'informations au sujet de l'aménagement déjà inexistant et sa fonction dans le passé.



Fig. 5. La vue de la Grande-Place, par le peintre – amateur Teofil Piątkowski, la 1^{re} moitié du XIX^e siècle.

anciens, ainsi que d'une collection de peinture, surtout du XIX^e siècle, conservant dans les représentations de la ville la forme des édifices aujourd'hui inexistantes ou transformés. Une autre partie de l'iconographie est constituée par une collection de photographies, jouant – depuis la deuxième moitié du XIX^e siècle – le rôle principal dans la documentation du paysage urbain.

La collection de la section Gravure n'est pas très ample: elle compte presque quatre mille estampes, dessins et aquarelles. Sa valeur provient de son profil: les ouvrages y sont rassemblés surtout en tant que documentation de l'aspect et des transformations de la ville. Les vues générales de Cracovie et ses environs, datant du XV^e au XX^e siècles, sont l'un des ensembles graphiques d'une plus grande valeur. Les dessins et aquarelles d'artistes du XIX^e siècle constituent aussi un matériel précieux. Les inventaires sous forme dessinée de portails, attiques, cours et vestibules anciens, constituent une section à part.

Les collections du Musée Historique rassemblent un matériel important et utile. En vue de la reconstitution, on profite de toute l'iconographie disponible dans les autres musées et institutions.

Les fonds iconographiques se caractérisent particulièrement par leur valeur artistique variée. Du point de vue des besoins de la reconstitution, l'importance de la collection est jugée indépendamment de ses valeurs artistiques. On peut même parler d'une certaine tendance: plus élevé est le niveau artistique d'une création, moins sa valeur iconographique apparaît comme considérable. Cette dernière ne dépend que de l'intention de l'auteur de rendre la vérité du réel. La valeur et, par conséquent, l'utilité d'un objet sont plus grandes, lorsque celui-ci présente un degré de réalisme plus haut. Ce qui est très caractéristique, c'est les créations d'amateurs et les créations naïves, qui peuvent être particulièrement appréciées pour leurs valeurs d'illustration (Fig. 5).

On peut diviser les sources iconographiques en quelques groupes:

5.4.1. Les vues graphiques anciennes de Cracovie

Dans la plupart des cas, ce sont des panoramas de la ville créés à l'époque moderne. Exécutés habituellement à partir de plusieurs points de vue, réunis en une seule composition, ils constituent l'expression d'une certaine vérité sur Cracovie. Parmi de nombreux, peu furent créés avec la connaissance de la ville. La majorité sont des copies reproduisant les versions antérieures. Ils fournissent un savoir général au sujet de l'aménagement urbain. Un petit nombre, dont le cuivre cité plus haut, sont utiles à la reconstitution de détails (par exemple de dômes de tours).



Fig. 6. La promesse de Tadeé Kościuszko à la Grand-Place en 1794, par Michał Stachowicz.

5.4.2. L'iconographie d'événements

Les tableaux et dessins, créés depuis la fin du XVIII^e jusqu'au milieu du XIX^e siècle en tant que commémorations d'événements marquants à Cracovie, sont d'une importance particulière. Tendant à une fidélité photographique, ils documentent avec le même soin les événements en tant que tels et le fond, c'est-à-dire l'aménagement urbain. Ce sont les premières vues de la ville considérée de l'intérieur. Dans la plupart des cas, elles représentent la Grand-Place (Fig. 6.)

5.4.3. Les dessins et aquarelles intentionnellement créés comme documentation
Ceux-ci, dans la première moitié du XIX^e siècle, alliaient l'émerveillement romantique devant les monuments du passé avec l'objectivité d'observation issue de l'esprit du siècle des lumières. Leur forme, souvent très modeste (esquisses, par exemple), se caractérise par une grande crédibilité, vu la richesse d'information qu'ils fournissent (Fig. 7.)

5.4.4. Paysages urbains

Cette sorte de peinture, de plus en plus populaire depuis le début du XIX^e siècle, est d'une grande variété en ce qui concerne les valeurs artistiques et iconographiques. Le plus souvent, le jugement de la valeur iconographique exige une analyse comparative.

5.4.5. Photographie

Depuis la deuxième moitié du XIX^e siècle, Cracovie possède une très riche iconographie conservée grâce à la technique photographique. Elle nous transmet l'image de la ville après des changements considérables (démolitions et transformations de la première moitié du XIX^e siècle). Ce qui constitue l'avantage de la photographie, c'est son objectivité complète.

5.5. Analyse des sources d'archives

Les sources que l'on peut dire écrites, concernant les biens immobiliers, ne sont pas nombreuses. Les plus importantes sont les révisions et inventaires effectués en rapport avec des héritages ou donations. Elles comprennent le plus souvent des descriptions d'immeubles et d'équipements, ainsi que des registres d'appareillage. La plupart du temps, ceux-ci ne sont pas complets du point de vue de nos besoins. Cependant ils constituent parfois une source fondamentale, fournissant des informations essentielles, par exemple en ce qui concerne le nombre d'étages, le genre de la couverture du toit etc.



Fig. 7. L'Hotel de Ville, par Józef Brodowski, 1820.

5.6. Analogies

En cas de manque complet d'iconographie ou de sources pauvres ou imprécises, il reste une seule voie de reconstitution de l'aspect des édifices ou de leurs fragments, à savoir une quête d'analogies parmi les exemples architectoniques conservés, manifestant des rapports avec l'architecture cracovienne. Ce qui est utile, c'est l'analyse des constructions imitant des édifices de Cracovie, projetées ou exécutées par les mêmes architectes ou ateliers de construction. On cherche enfin des rapports et analogies parmi les réalisations semblables situées dans les mêmes sphères d'influences.

6 – L'hypothèse comme résultat de l'interprétation des sources par les auteurs

Comme je l'ai souligné maintes fois, la reconstitution des édifices particuliers et des complexes de bâtiments n'est pas la solution définitive du problème. Elle est une interprétation des sources définies, par des personnes disposant d'un savoir et d'une expérience déterminés.

Sans doute, la reconstitution élaborée dans le cadre de notre projet n'apportera pas une solution définitive. On sait déjà que le projet sera continué et développé dans l'avenir. Le résultat de notre travail de deux ans, dont l'achèvement est prévu pour 2007, pourra constituer le point de départ et un repère pour les élaborations futures.

7 – La base de données comme fondement de l'hypothèse

Afin de pouvoir prolonger les recherches, il est indispensable d'assurer une base de données, convenablement reliée au modèle, concernant les sources et la bibliographie avec les commentaires d'auteurs. Les données doivent être facilement accessibles et ordonnées selon un principe clair.

8 – Les avantages de la méthode adoptée. „Nouvelle iconographie” de la ville ancienne.

Le modèle numérique de l'aménagement urbain d'autrefois confirme actuellement sa valeur en tant qu'un éminent outil, élargissant l'atelier de l'historien et de l'historien de l'architecture. Dans plusieurs cas, c'est la seule méthode permettant de reconstituer la forme des édifices; très souvent, elle rend possible une vérification des résultats de recherches obtenus jusqu'à présent. Le modèle numérique exclut toute simplification, ainsi que la tendance fréquente à subordonner des conditionnements pratiques au certaine théorie. Il exclut également les imprécisions des mesures. Il accorde toutes les interdépendances: proportions des bâtiments, résistance de la construction, disposition des locaux, voies de communication, et aussi valeurs de style et



a



b

Fig. 8.a,b. L'aménagement de la Grande-Place. Réconstitution numérique. (consultation scientifique: W. Komorowski, T. Węclawowicz; graphique: P. Opaliński, W. Mazurek)

esthétiques. Il tient compte également des facteurs résultant des règlements en matière de constructions ainsi que des solutions pratiques, comme par exemple l'évacuation de l'eau ou les fonctions des bâtiments (Fig. 8 a,b).

Les reconstitutions effectuées avec cette méthode réduisent au minimum les erreurs et l'arbitraire de l'interprétation des sources. On peut dire aujourd'hui, avec une certaine assurance, qu'en reconstituant les édifices sous forme de modèles numériques, nous nous sommes en train de créer une nouvelle iconographie de la ville dans sa forme ancienne et passée (Fig. 9. a,b).

9 – Les dangers de la méthode adoptée

La méthode de reconstitution adoptée pendant la première étape d'élaboration du projet n'était pas considérée comme une fin, mais comme une méthode auxiliaire servant à la création d'une maquette plastique. Celle-ci devait être le résultat d'une élaboration scientifique globale. Le mode de travail de toute l'équipe a été subordonné à cet objectif supérieur.

Un inconvénient a surgi, résultant de la rapidité exigée de l'exécution. Le projet prévoyait initialement un archivage électronique simultané des sources et de la bibliographie nécessaire, facilement accessibles à partir du modèle établi. Les termes imposés de la réalisation permettent uniquement de conduire une documentation courante, mais sans la relier aux composantes du modèle. Cette partie du projet sera complétée à l'étape suivante des travaux.

10 – Conclusion

Le projet réalisé au Musée Historique de la Ville de Cracovie n'a pas de précédent en Pologne. Pour la première fois a été menée une collaboration à une telle échelle, d'une telle étendue et regroupant autant de spécialistes de multiples disciplines, visant un but commun déterminé. Dans ce sens, le projet accomplit également la fonction importante d'intégrer les efforts de différents milieux professionnels (voir la note 1).

Le projet actuel vise une reconstitution de l'aménagement de la ville en deux étapes et dans deux extensions, avec un degré varié de la présentation du détail. Il est établi et réalisé en respectant le principe que les reconstitutions doivent être fidèles, dans les cas incertains proposant une hypothèse, mais toujours avec une indication de sa probabilité. La reconstitution exécutée présentement est l'effet d'une certaine interprétation des sources. On ne pourra jamais affirmer qu'elle constitue une élucidation définitive du problème, mais uniquement une solution proposée, possible et acceptable, conforme à l'état actuel des connaissances ainsi qu'à l'interprétation des données admise (Fig. 9. a,b.). La réalisation finale du projet sera dans l'avenir le point de départ de compléments et continuations (Fig. 10.).

Note 1. Pour finir, convient de mentionner, comme un avantage résultant du projet, la constitution d'une équipe expérimentée, avec une méthode élaborée, pouvant continuer avec succès les travaux dans le futur.



Fig. 9 a,b. L'aménagement de la plus ancienne partie de la ville, nommée Okól. Réconstitution numérique. ((consultation scientifique: W. Niewalda, H. Rojkowska, graphique: M. Rzepecki)

Il faudra donc tenir compte d'un élargissement possible de l'état de notre savoir, qui pourra être pris en considération dans les suites du projet.

Aujourd'hui déjà on peut dire que le présent projet commence un programme de recherche beaucoup plus important. Ce programme élargi d'élaborations plus détaillées pourra jouer un rôle majeur pour la conservation et la préservation du patrimoine national.

Il pourra acquérir prochainement une valeur pratique effective. Grâce à l'établissement d'un *sui generis* catalogue des objets d'architecture ancienne, accompagné d'une information au sujet de leur fonction, il pourra être utile dans l'élaboration de projets architectoniques et programmes de restauration contemporains. La pratique précédente manifeste un manque d'études intégrales dans ce domaine; et le problème est signalé aussi par les architectes. Les traitements commandés en vue des restaurations particulières n'accomplissent pas cette fonction de manière parfaite, vu leur caractère fragmentaire, et non global. Cracovie en tant que ville vivante ne saurait être condamnée au manque d'investissements en matière de constructions, mais la mise en place d'une architecture moderne au sein du centre historique de la ville exige des précautions et une prudence particuliers, afin de respecter avec compréhension la structure ancienne, sans l'endommager et, surtout, la détruire. Car de telles actions ne sont pas seulement nuisibles, mais aussi irréversibles.

Un objectif important d'un tel programme est d'éduquer et de promouvoir le savoir sur le patrimoine national. La „Nouvelle iconographie” de Cracovie pourra être promue et employée avec succès dans les publications multiformes, des manuels aux différents intérêts jusqu'aux guides, programmes interactifs, films et autres formes qu'on ne peut énumérer ici.



Fig. 10. La réconstitution du château royal ; l'état env. 1650. (consultation scientifique: K. Czyżewski, graphique: M. Rudek)

De l'acquisition des données spatiales à la représentation architecturale : le cas des vestiges du théâtre antique d'Arles

Principes pour un système d'informations architecturales 3D.

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Pour étudier un édifice patrimonial on fait appel à des informations hétérogènes et à des technologies différentes. Plusieurs types d'informations (qualitatives et quantitatives) liés au bâtiment et plusieurs types de technologies utilisés pour son étude (technique de relevé ou de représentation 2D ou 3D) peuvent nous apporter des connaissances différentes et complémentaires de l'objet étudié. Notre objectif est d'exploiter ces connaissances issues des différents types d'analyse de l'architecture patrimoniale (documentation, relevé, modélisation, représentation etc.) et de le rendre accessibles à partir d'une plateforme commune.

Notre proposition expérimentée sur les vestiges du théâtre antique d'Arles considère le modèle 3D interactif comme moyen d'accès privilégié à l'information patrimoniale. Le dispositif mis en place permet, par l'interaction avec la maquette 3D temps réel de l'objet d'étude, la navigation dans les jeux d'informations qui le caractérisent.

Au cœur de ce système d'informations architectural 3D en devenir, un modèle de description de l'édifice utilisant des termes univoques appartenants au vocabulaire d'architecture sert de pont entre les éléments composant l'édifice et les informations relatives stockées dans une base de données.

Mots-clés

Relevé d'architecture, photomodélisation, 3D temps réel, gestion d'informations.

Catégories

E.1, H.4.m, J. 5.

1 - Introduction

Le relevé d'architecture est l'outil privilégié d'observation et d'analyse des édifices. Les techniques et les outils actuels d'acquisition des données spatiales (scanner laser 3D, photomodélisation, etc.) permettent la restitution des aspects dimensionnels sous forme d'un nuage de points, constituant ainsi un support pour les opérations suivantes de restitution géométrique de la morphologie de l'objet.

Si l'on part de l'hypothèse d'utiliser le modèle tridimensionnelle comme support d'accès aux informations, l'élaboration de ce modèle architectural impose la structuration d'un ensemble d'entités géométriques aptes à représenter la relation entre l'objet et les informations qu'il contient. L'édifice doit être alors décrit comme une collection d'objets élémentaires organisés par un ensemble de relations correspondant à une transcription en termes de géométrie du vocabulaire de l'architecte.

Une représentation architecturale dépend d'un objectif. Cet objectif détermine le choix de la méthode, des procédures et des outils à utiliser. La phase de réalisation d'une maquette utilise en fait l'information organisée dans la modélisation de l'objet architectural. Ce modèle peut être considéré comme une sorte de matrice d'informations dont on extrait les contenus de la représentation. Il s'agit donc de conduire la description des édifices s'appuyant sur l'intégration globale et cohérente des phases de relevé, modélisation et représentation (*cf.* [1]).

Avec ce travail, nous avons essayé d'exploiter les potentialités offertes par différentes techniques issues des domaines de l'acquisition des données spatiales, de la gestion d'informations patrimoniales ou encore de la modélisation tridimensionnelle en temps réel, pour tracer les principes d'un système d'informations architecturales 3D. Un système permettant d'étudier au sein d'une plateforme unique le jeu de connaissances issues des différentes phases d'analyse de l'édifice (relevé, modélisation, documentation, représentation). Ce jeu de connaissances formalisées, assemblées autour d'éléments non ambigus (formes architecturales observées ou théoriques), sert de fil conducteur depuis l'acquisition de données spatiales jusqu'à la représentation dans une maquette 3D temps réel servant d'interface de navigation.

Cet article est organisé à l'image de la démarche adoptée : la section 2 présente une brève description de l'objet d'étude. La section 3 décrit les techniques de relevé utilisées pour l'acquisition des données spatiales. La section 4 aborde le problème de la restitution tridimensionnelle des éléments architecturaux à partir des informations métriques acquises en phase de relevé. La section 5 présente la stratégie utilisée pour la structuration de la maquette en vue de sa liaison avec la base de données. La section 6 termine cet article avec des réflexions conclusives. Cette contribution présente de façon approfondie une expérience dont certains aspects ont déjà fait l'objet d' (*cf.* [2], [3]).

2 - Le théâtre antique d'Arles

Le terrain d'expérimentation est le théâtre antique d'Arles et plus particulièrement son bâtiment de scène. Ce théâtre qui date de la fin du I^o siècle av. J.-C. est aujourd'hui largement détruit. Du bâtiment de scène, il ne reste en pied que des parties de colonnes et une partie du podium (Fig. 1). Par contre, sont conservés sur le site beaucoup de fragments d'éléments qui faisaient partie des trois ordres du front de la scène. De plus, le Musée de l'Arles Antique conserve diverses statues qui ornaient les niches situées dans le mur de scène. Une statue du théâtre, la Venus d'Arles, est exposée au musée du Louvre.

En ce qui concerne les ressources documentaires relatives au théâtre d'Arles, la situation reste la même : un grand nombre de documents, photographies, textes antiques, gravures, etc., se trouvent éparpillés dans les différentes archives ou bibliothèques de France.

La dispersion des vestiges et de documents concernant le théâtre rend difficile la compréhension du monument sous différents aspects : historique, morphologique, etc. Le théâtre antique d'Arles représente donc un terrain d'étude emblématique pour ce travail qui vise à la réalisation d'un support unique d'accès aux informations. La restitution 3D du bâtiment de scène repositionnant les fragments originaux, mesurés, entre les volumes virtuels d'un modèle théorique du théâtre augustéen, permet non seulement d'accéder à un jeu de données hétérogènes, mais aussi de comparer visuellement différentes représentations du même objet (recomposition hypothétique, état actuel, etc.). Elle permet également d'évaluer par rapport à leur taille et à leur morphologie l'appartenance de chaque fragment à une typologie établie (comparaison connaissances générales/objets particuliers) et d'étudier ses emplacements hypothétiques dans le bâtiment originel (investigation des vestiges).

3 - Relevé et inventaire des vestiges

3.1. Photomodélisation des fragments

La technique utilisée pour le relevé des fragments conservés in situ et dans le Musée de l'Arles antique est la photomodélisation. Il s'agit d'une technique de restitution photogrammétrique à partir d'un bloc multi-image. Quatre photographies minimum ont été prises pour chaque fragment (Fig. 2). Pour le relevé, on peut utiliser des photographies convergentes, horizontales, verticales ou obliques. Le processus de restitution des coordonnées spatiales se base sur l'ajustement des blocs d'images par la méthode des faisceaux (*cf.* [4]) à partir d'un ensemble de correspondances (points homologues) sélectionnées sur les photographies. Cette méthode présente différents avantages en ce qui concerne sa flexibilité en phase d'acquisition : la mise en place sur le terrain d'une configuration d'acquisition photogrammétrique multi-image est très



Fig. 1. Le théâtre antique d'Arles [aut. F. De Domenico, 2003]

rapide et la quantité d'informations contenues dans une seule photographie (aujourd'hui jusqu'à 12 millions de pixels pour un reflex numérique), assure un niveau de précision métrique important.



Fig. 2. Photomodélisation d'un fragment de corniche du frons scaenae du théâtre [aut. F. De Domenico, 2003]

Ceci rend cette technique particulièrement indiquée pour l'acquisition photographique des fragments archéologiques, souvent difficiles à déplacer. L'acquisition photographique permet un déplacement plus facile autour de l'objet et augmente de façon considérable le nombre de prises de vue enregistrables dans une campagne de relevé.

Les résultats de la photogrammétrie multi-image peuvent être des modèles filaires en 3D, mailles triangulaires construites sur l'ensemble des coordonnées extraites (Fig. 3), ou des photomodèles, représentations géométriques enrichies par les textures (Fig. 4).



Fig. 3. Modèle filaire du fragment construit à partir des points homologues sélectionnés sur les photographies [aut. F. De Domenico, 2003]

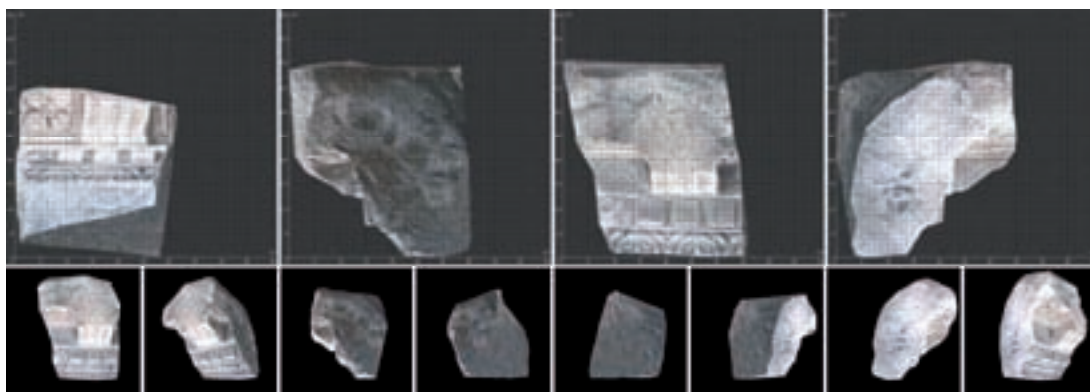


Fig. 4. Restitution tridimensionnelle du fragment [aut. F. De Domenico, 2003]

Jusqu'à présent, la simulation des matériaux a été abordée par des techniques et des outils mal adaptés pour représenter la complexité des traces que le temps a laissé sur la "peau" des édifices. Au contraire la photomodélisation peut être considérée comme une technique qui permet la description des objets en se basant sur l'intégration globale et cohérente des phases de relevé, modélisation et représentation (cf. [1]). En effet, les textures étant extraites à partir des photographies originales, permettent de représenter l'objet en trois dimensions de la manière la plus réaliste possible.

3.2. Analyse et classification des fragments relevés

La phase de relevé nous a permis de développer un catalogue tridimensionnel des fragments et des vestiges du bâtiment de scène (Fig. 5). La campagne de relevé a concerné des parties de corniche, de bases, des colonnes sur le site du théâtre mais également une corniche presque intacte, un chapiteau et la statue monumentale d'Auguste au Musée de l'Arles antique.

Cet inventaire nous a permis de comparer les fragments relevés sous différents aspects : taille, morphologie, matériaux et motifs de décor dans le but d'en conduire une classification. Ce type d'analyse croisée a permis par exemple d'identifier les fragments de corniche appartenant aux trois ordres du bâtiment de scène.

Dans le même sens, une observation approfondie des détails et des dimensions de ces fragments a permis d'isoler des modèles théoriques de référence pour l'étape suivante de restitution des formes originelles.

4 - Restitution 3D de l'objet architectural

4.1. Modélisation 3D des éléments à partir des données acquises

Plusieurs travaux (cf. [5], [6]) se sont concentrés sur la représentation d'hypothèses de restitution d'édifices disparus ou partiellement détruits s'appuyant sur les techniques d'infographie 3D. Une réflexion est par contre nécessaire à ce propos. En effet, si pour la restitution de l'état actuel d'un édifice, la demande de réalisme peut trouver des justifications dans la volonté de pouvoir apprécier l'état de conservation des matériaux qui le composent, en ce qui concerne la représentation des états antérieurs, il est important de réfléchir sur l'adéquation des techniques de représentation par rapport à la rigueur qu'une visualisation scientifique requiert.

Cette expérience a été pour nous l'occasion de souligner l'importance de véhiculer dans la représentation de l'édifice le degré d'incertitude qui est à la base de sa restitution hypothétique. Cette approche est fondée sur le choix d'associer à la représentation de l'édifice une indication de l'état de connaissance qui justifie sa restitution (cf. [7]).



Fig. 5. Catalogue tridimensionnel des fragments relevés [aut. F. De Domenico, 2003]

La représentation de l'édifice s'appuie donc sur la simple comparaison métrique entre des modèles théoriques (en filaire) dimensionnés sur les fragments relevés (Fig. 6, Fig. 7). Cette opération est conduite par instanciation (positionnement et déformation) d'un ensemble de primitives architecturales formalisées à partir des traités d'architecture (cf. [8], [9]).

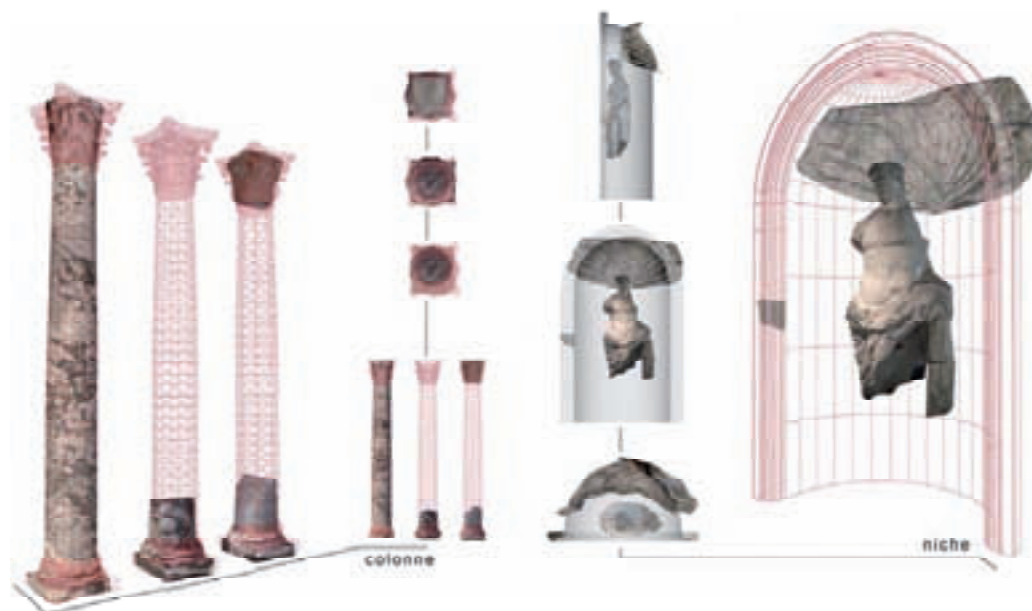


Fig. 6. Restitution 3D des éléments théoriques du bâtiment de scène à partir du relevé des vestiges [aut. F. De Domenico, 2003]

4.2. Modèle de description de l'objet architectural

Comme nous l'avons déjà dit, l'objectif final de la phase de restitution consiste à lier des informations structurées à la maquette 3D pour pouvoir se servir de cette dernière comme outil de navigation dans la documentation. Pour cela, nous devons nécessairement concevoir un modèle de description de l'édifice valable à la fois pour sa reconstruction tridimensionnelle mais aussi pour structurer les informations dans une base de données. Or, ce travail n'est possible qu'à condition que le jeu de connaissances relatives à l'objet architectural traité soit formalisé. Un système de connaissances architecturales peut être décrit comme une collection d'objets structurés identifiés par un vocabulaire précis (cf. [10]). Mais la description de la structuration de ces objets dans un ensemble ordonné nécessite l'observation d'ordre plus complexe. Goulette



Fig. 7. Restitution 3D des éléments théoriques du bâtiment de scène à partir du relevé des fragments [aut. F. De Domenico, 2003]

(cf. [11]) identifie trois types de relations entre les éléments que l'on peut lire dans le vocabulaire de l'architecte : les relations topologiques, les relations partie-ensemble et les relations de composition. Nous concentrons notre attention sur les relations partie-ensemble qui expriment des logiques de structuration hiérarchique d'une composition architecturale. Il s'agit des relations qui expriment les ensembles architecturaux en fonction d'une logique fondée sur l'analyse de la composition de l'édifice. La figure suivante présente l'analyse des relations hiérarchiques du modèle théorique du front de la scène d'un théâtre romain de période augustéen (Fig. 8).

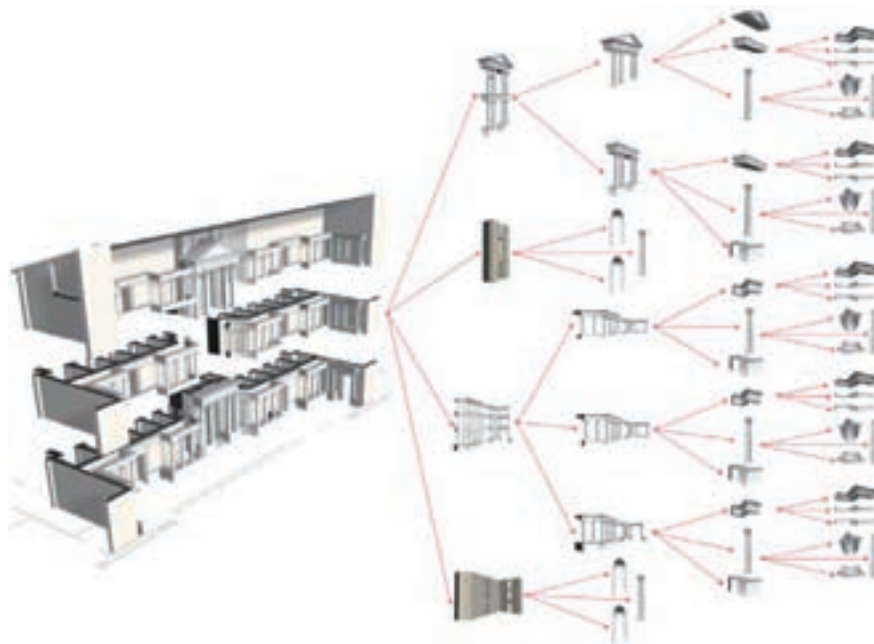


Fig. 8. Modèle de description du bâtiment de scène restitué [aut. F. De Domenico, 2003]

La structure de description visant à représenter les relations hiérarchiques entre les éléments utilise cinq niveaux. Pour donner un exemple : un chapiteau, qui fait partie d'une colonne, qui fait partie d'une colonnade qui fait partie du front de la scène. La maquette 3D ainsi réalisée a servi aussi comme support pour l'élaboration d'images pour l'évaluation de l'hypothèse de restitution au travers d'une superposition réel/virtuel (Fig. 9).

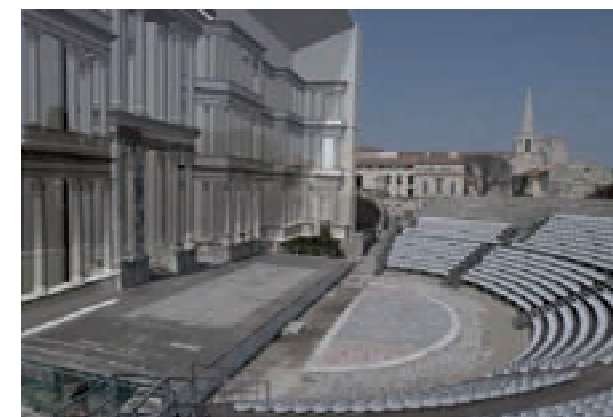


Fig. 9. Deux superposition réel/virtuel : les volumes hypothétiques sont incrustés sur les photographies de l'état actuel du théâtre [aut. F. De Domenico, 2003]

5 - Principes pour un Système d'Informations Architecturales 3D

5.1. Problématique

Dans l'étude d'un édifice, au delà du relevé, le développement de descriptions qualitatives est un domaine de recherche beaucoup plus vaste. Il apparaît donc essentiel aujourd'hui d'étudier les conditions au travers desquelles les informations quantitatives, extraites du relevé et les informations qualitatives, produites par l'interprétation des données acquises ou par l'analyse de sources documentaires, peuvent être analysées à l'intérieur d'une plateforme unique et intégrée. Il s'agit en effet d'une problématique complexe qui nécessite l'interaction de trois aspects distincts :

- *Le modèle de données*, qui définit la manière dont les informations hétérogènes sont organisées, stockées et indexées dans une base de données ;
- *La représentation géométrique* qui concerne la relation entre un type de représentation (nuages de points, structures filaires, mailles polyédriques ou géométrie enrichie) et le type d'informations qu'elle véhicule (dimensions, structure, volume, apparence visuelle, etc.). De plus on s'intéresse à la manière dont ces représentations sont accessibles à la consultation et/ou à la manipulation ;
- *Un modèle de description de l'édifice* qui constitue le noyau central de l'intégration entre informations quantitatives et qualitatives. Cet aspect concerne la stratégie utilisée pour structurer des informations autour de la morphologie de l'objet et les modalités d'accès aux données.

Dans notre cas, comme nous analysons des vestiges, la stratégie de structuration d'informations hétérogènes choisie s'appuie sur le modèle de description de l'hypothèse de restitution réalisée.

5.2. L'architecture du système

Le système développé est basé sur une architecture en trois parties qui répondent à trois exigences distinctes :

- *Stockage de données hétérogènes*. Une base de données organise les maquettes 3D des vestiges, les fiches de description des fragments et des modèles théoriques ainsi qu'un ensemble de sources documentaires numérisées ;
- *Manipulations de représentations géométriques tridimensionnelles en temps réel*. Une scène 3D interactive permet l'affichage et la manipulation des représentations 3D ;

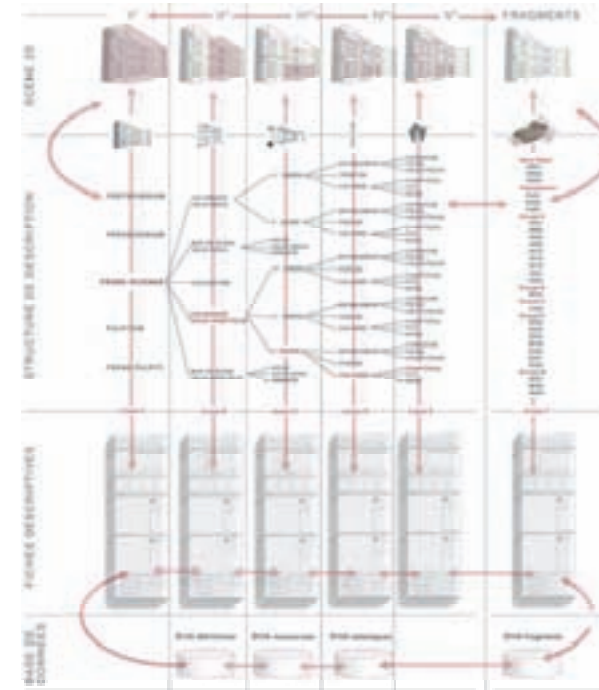


Fig. 10. Les relations entre la scène 3D, les fiches descriptives et la base de données [aut. F. De Domenico, 2003]

- *Consultation et gestion des données en ligne.* L'application est développée autour d'un site Internet qui constitue l'accès utilisateur aux données stockées dans la base et fournit les passerelles nécessaires pour le dialogue entre la scène 3D et les informations hétérogènes.

La structure de description permet d'établir des relations bilatérales entre des informations structurées et la scène 3D (Fig. 10). Cela permet d'isoler des éléments dans la scène 3D, en isolant en même temps un concept, un terme auquel on attache des informations spécifiques. En effet, l'organisation des informations suit le modèle de description de l'édifice : aux cinq niveaux d'approfondissement de la scène 3D, correspondent cinq niveaux d'organisation des informations. Le modèle de description de l'édifice constitue alors le pont entre les niveaux d'observation, à la fois dans la scène 3D et entre les informations structurées dans une base de données. Cette base contient les définitions des éléments et un ensemble de ressources qui s'y rattachent (photos, gravures, etc.). Aux fiches relatives aux éléments de vocabulaire, s'ajoutent celles des fragments dans lesquelles on retrouve les informations sur leur localisation, leur état de conservation, leurs matériaux, leurs dimensions, etc.

5.3. L'interface du système

En conformité avec son architecture, l'interface du système est caractérisée par trois éléments principaux (Fig. 11). En haut à gauche, la scène 3D interactive (Fig.12), dans laquelle on peut sélectionner des éléments dont on récupère la position dans la structure de description située en bas à gauche. Les fiches informatives (à droite) affichent les données relatives aux entités sélectionnées dans la scène 3D. La représentation tridimensionnelle est en définitive une interface qui permet à l'utilisateur de :

- Sélectionner un élément par son nom dans la structure hiérarchique et visualiser sa position dans la scène ;
- Obtenir des fiches d'informations en relation avec cet élément ;
- Sélectionner un élément dans la scène 3D et visualiser sa position dans la structure hiérarchique ;
- Changer le niveau d'observation courant (entre les cinq niveaux) ;
- Visualiser/masquer les éléments ou des groupes d'éléments ;
- Contrôler de façon interactive les niveaux de transparence des éléments et des groupes d'éléments ;
- Visualiser/Masquer les fragments et les vestiges dans l'espace 3D.



Fig. 11. L'interface du système d'informations architecturales 3D [aut. F. De Domenico, L. De Luca 2003]

6 - Conclusion

Cette expérience nous a permis d'évaluer l'apport que la maquette 3D peut fournir dans un dispositif de visualisation d'informations et de connaissances relatives à des vestiges archéologiques. Plusieurs conclusions peuvent être tirées à la fin de cette expérience. Notamment, il est important de remarquer l'apport donné par le modèle de description à la structuration des informations et des représentations. Cependant, si d'un côté il faut insister sur la nécessité de construire cette maquette à partir des connaissances de base de l'architecte exprimées par son vocabulaire, de l'autre côté il faut retenir que cette structure de description n'est pas forcément unique car la décomposition morphologique d'un édifice dépend toujours d'un objectif d'analyse.



Fig. 12. La scène 3D interactive [aut. F. De Domenico, L. De Luca 2003]

Références bibliographiques

- [1.] M. Florenzano, / L. De Luca, “*Relever, modéliser, représenter le patrimoine construit*”, [in] II^o Rencontres Internationales Monaco et la Méditerranée - Nouvelles technologies au services de la protection du patrimoine méditerranéen et de la diffusion de sa culture, Association Monégasque pour la Connaissance des Arts, Monaco 2003
- [2.] J.-Y. Blaise et al., “*Acquisition de données vs gestion de connaissances patrimoniales : le cas des vestiges du théâtre antique d'Arles*”, [in] EGC 2004 - 4^{èmes} journées d'Extraction et de Gestion des Connaissances, Clermont Ferrand 2004
- [3.] J.-Y. Blaise et al., “*Architectural Modelling and Information Interfacing: Learning from Three Case Studies*”, [in] ITI 2004 - 26th International Conference on Information Technology Interfaces, Cavtat / Dubrovnik 2004
- [4.] O. Faugeras, “*Three-Dimensional Computer Vision : A Geometric Viewpoint*”, MIT Press, Cambridge, Massachusetts 1993.
- [5.] F. Lecocq, “*Reconstruction virtuelle de Rome antique*”, [in] Proceedings of Virtual Retrospect, Biarritz 2003, pp. 77 - 84
- [6.] B. Frischer, “*Mission and recent projects of the UCLA cultural virtual reality laboratory*”, [in] Proceedings of Virtual Retrospect, Biarritz 2003, pp. 65-74
- [7.] I. Dudek et al., “*Exploiting the Architectural Heritage's Documentation: A Case Study on Data Analysis And Visualisation*”, [in] Proceedings of I- KNOW '03, Graz, Austria 2003
- [8.] F. Dekeyser et al., “*Cultural heritage recording with laser Scanning, computer vision and exploitation of Architectural rules*”, [in] International Workshop on vision techniques for digital architectural and archaeological archives, ISPRS WG V/4 and IC WG III/V, Ancona 2003
- [9.] L. De Luca et al., “*Reverse engineering of architectural buildings based on a hybrid modeling approach*”, *Computers & Graphics*, Elsevier, April 2006, vol. 30, issue 2, pp. 160-176
- [10.] P. Quintrand et al., “*La CAO en architecture*”, Hermes, 1985
- [11.] J.-P. Goulette, “*Sémantique formelle de l'espace : Application au raisonnement spatial qualitatif en architecture*”, *Intellectica : Revue de l'Association pour la Recherche Cognitive*, 1999, N^o29, pp. 9-34

Less is more. Visual truth and the benefits of abstraction in 3D representations of buildings

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Building digital urban environments and more precisely virtual heritage focuses on graphical representations as abstractions of reality. 3D models of cities are, just as the maps they are based on, only representations of the built environment: their content stays open for discussion. The interpretation of the resources requires much knowledge about their conventions in order to be able to select accurate information. Further, the level of detail and accuracy needed depends very much on the purpose a city model is to serve.

The representation of time is another issue complicated enough to explore in more detail. Despite numerous experiments in building time lines over the last fifteen to twenty years, still no sufficient model is available for showing urban change and transformation.

The prime question, superseding all others is still: Why!?? Why are we building digital 3D reconstructions of architecture? Why do we need photo realism? What is the reason behind the graphics and how much information do we need to include and what information should we omit? How can we create models that are reusable for other purposes as well, so that the work is justified. Once we understand that there are different solutions for each individual problem, new conventions in the representation of architecture can be created. These will ultimately lead to new ways to reuse the results of virtual heritage as resources for new research and development.

Key Words:
**Virtual Heritage,
Visualization, Graphical Representation, Reconstructions of Cities**

1 - Introduction

This article is all about the digital representations of existing cities, or *digital urban environments*. When dealing with architectural or archaeological heritage one usually speaks of: *Virtual Heritage*. One definition of visualization is: *A formal representation or an aspect of a problem, idea or system* Visualization (graphic), as in any technique for creating images, diagrams, or animations to communicate any message. Scientific visualization, an application of computer graphics which is concerned with the presentation of potentially huge quantities of laboratory, simulation or abstract data to aid cognition, hypotheses building and reasoning Knowledge visualization, a sub discipline of Information Design and Instructional Message Design. [en.wikipedia.org]. Staley remarks that visualizations are often *maps of the mind*. [Staley 2003].

Visualization has several important characteristics: it is a *virtual reality* that is often *Immersive*; it is *Interactive* and it supports *augmented reality*. Philosopher Jos de Mul speaks in this respect of *connectivity, multi mediality, interactivity and virtuality*. [De Mul 2002] Virtuality and virtual reality refer to the state that it is not real but it approaches reality in a sense that people can experience it (Immersive) as well as that they could interact or play with it (Interactivity). Connectivity (Internet/Intranet) is a basic characteristic as well as the fact that visualization typically uses more than one medium (multi mediality).

3D representations of cities are made for various purposes such as archeological research, historical reconstructions, tourist and educational information, urban planning, etc. They may display just the basic outlines and volumes of masses distinguishing the built up areas from the open areas or they may be rendered in detail. There are two ways for starting building a historical 3D model from maps: the first method is to start with the present state using accurate current maps and interpret changes back in time. The second way is to start with old maps that are compared to current maps based on reference points.

Sources for 3D representations

The creation of visual representations is all about conventions: conventions for interpretation, conventions of form and use, symbols for details in order to read the information. Conventions in depictions are always related to time and culture. We are taught by our cultural background how to “read” and interpret these conventions. Just like cultural phenomena gradually change over time, so do conventions and likewise interpretations can change or can even get lost.

Using historical sources such as maps, it is important to know and interpret the purpose of the original maps, such as fortification maps, designs or plans, historical maps, news maps, commercial maps, juridical maps, cadastral and GIS-mapping, terrestrial and aerial images, etc. In order to be able to extract useful data, the level of accuracy and reliability of each of these

maps needs to be determined, its background information analyzed and the map compared with other maps and written sources.

Historical and cartographical material always needs to be analyzed thoroughly. When using maps for creating 3D models it is perhaps even more important than ever, to document its sources and decisions taken during the process since the models will serve as sources for further research.

Graphical representation of architecture

The architectural drawing itself can be considered a means to communicate aspects of buildings in different architectural projections, for instance, plans, elevations, roof plans, sections, perspectives, axonometrics and isometrics. In architectural practice, an architectural object is mostly represented by orthogonal projections: a plan, elevations, and sections. Orthogonal projections represent objects without optical distortion. Agreements are made on the way walls, doors, windows, and other elements are represented in drawings. Because of these conventions, one usually has to learn how to *read* them. In the architectural analysis of buildings, other kinds of visual material are added, such as reconstruction drawings involving (all) phases of a building, photographs, paintings, and drawings of details.

Whereas the more *technical*, orthogonal representations in architecture function to convey information as ‘facts’, clients of architects usually base their decisions on the perspective projection. Contrary to orthogonal projections, which are more difficult to interpret because of their conventions, the perspective projection is closer to the human perception and therefore easier to understand and interpret. For instance, Gordon Cullen's *Townscape* contains nothing but perspectives as seen through the human eye (approximately 1.60 meters). [Cullen 1961] He also presents *walks through* towns to grasp the fourth dimension (movement) by means of a series of different viewpoints, which he calls *serial vision*. In presentation drawings, buildings are also often represented in perspective in order to convey spatial information at a level understandable for a wide audience.

Benefits of abstraction

If we want to digitally reconstruct an object from the real world, reality can often be confusing caused by an overload of visual information. If we could break this information down into pieces and if we could succeed in agreeing how the information will be deconstructed and into what levels, it could ultimately lead to new conventions of graphical representation. In the humanities, and art-history in particular, where the work of art is considered almost sacred, deconstruction and abstraction of the object is often regarded as desecration. Many people



Fig. 1. Image from Gordon Cullen's *Townscape*, showing perspective views of a town at eye-level.

believe that as soon as a work of art has been deconstructed into different levels or changed for analysis, much of the secret of it will be lost for ever!

Although an unavoidable consequence of the process of abstraction is the loss of information, loss of information is, however, not always a negative consequence. Abstraction forces one to focus on the subject under study without being distracted by elements that are not relevant for a specific study. It allows one to ignore unnecessary details so that a selection of relevant elements, essential for carrying out a certain project, becomes apparent. If applied consistently, abstraction allows us to analyze different architectural objects in a uniform way, since all elements can be viewed at the same level of detail and at the same scale.

The fact that beautifully refurbished drawings had the effect of distracting the attention from the main structural appearance of a building was already recognized by Jean Nicolas Louis Durand in his *Recueil et parallèle des édifices* [Durand 1800]. In this book he juxtaposed line-drawings of buildings of the same type. The drawings were mostly at the same scale therefore they can be compared in form on the same level of detail, producing a catalogue of forms of each type. He wished to do away with all unnecessary extravagance and decoration in architecture. In this way, he reduced architecture and its representation to its structural and formal geometry. As an engineer he was more in favor of technical, abstract line-drawings than the refurbished drawings which were acceptable at the time, such as watercolors from the Ecole des Beaux-Arts [Drexler 1977]. Beaux-Arts representations mainly consisted of plans and elevations which were later lavishly rendered with shadows, colors, and decorative elements. In Durand's view, these refurbished drawings concealed the *essential* geometry of forms and buildings would be represented more *objectively* by orthogonal line-drawings stripped from superfluous details.

At the end of the 19th century, the notion of *objective*, abstract line drawings, as opposed to *subjective* perspective projections, led to the reintroduction of the axonometric projection. The axonometric projection became popular after Auguste Choisy had illustrated his book *Histoire de l'Architecture* (1899) with axonometric images. The axonometric provide information about the three-dimensional structure, the plan, and the elevations of buildings. There are no optical distortions parallel lines remain parallel until infinity. It was probably because of these qualities that The Style and the Modern Movement and more recently, Bruno Fortier, made extensive use of the axonometric, since it conveyed several kinds of information in a single image.

Level of detail

There are basically three types of digital urban environments to distinguish in which the level of detail is significant:

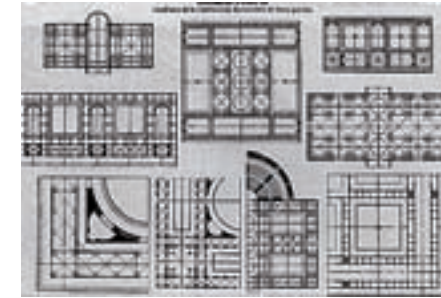


Fig. 2. Image from J.N.L.Durand's *Parallèle...*: juxtaposition of plans.



Fig. 3. Beaux Arts watercolor drawing with much detail.

Less is more. Visual truth and the benefits of abstraction in 3D

- Low level of detail: for planning, general overview and basic educational purposes
- Medium level of detail: Terrain model with buildings, building blocks
- High level of detail: includes texture mapping, light and movement effect such as virtual reality, radiosity etc. useful for nearby views of small reconstructions such as monuments, individual buildings etc.

It should be noted that visualizations or simulations never can replace reality they can only come close to reality from a specific viewpoint. Representation means always an abstraction of reality. It can only simulate realism. Abstraction means a known choice for what is or omitted, and how it is represented.

The problem of historical research is that often data is missing, incomplete, unclear and inconclusive.

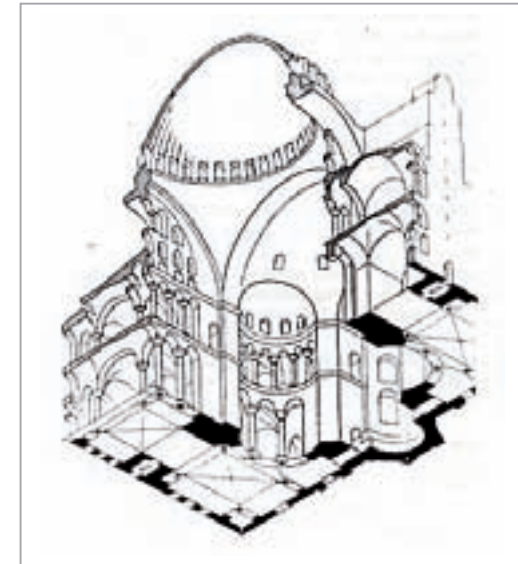


Fig. 5. Auguste Choisy: axonometric drawing.

Fig. 4. C.R. Cockerell: The Professor's Dream (1848): images of styles of all ages combined in a single view: which one to choose?

Academic purposes and reaching a wide audience

Although most 3D visualizations represent the current state of a city, many of them are created for the study and dissemination of knowledge of historical urban environments. An early project of using 3D reconstructions in architectural research was the case-study from 1993 about the urban and architectural development in the twentieth century of the fortified town of *Heusden* in The Netherlands.[Alkhoven 1993] The map by Joan Blaeu (1649) was ‘reconstructed’ based on its dimensions as shown in the map. This reconstruction helped to understand the reliability of the old map in comparison to up to date accurate measurements. It also made apparent that Blaeu had applied a kind of typology in representing the houses in town. Thus, seventeenth-century cartographers not only made use of two-dimensional symbols and cartographic conventions, they also applied it to three-dimensional information!



Fig. 6a. Photograph of the fortified town of Heusden The Netherlands (1990).

Fig. 6. Reconstruction of Heusden's townscape (1991) based on Map by Joan Blaeu (1649).

Unfortunately many 3D computer models do not come with detailed documentation about their sources. They are just there, for everyone to admire, even if one does not know what to look at!

The more detailed the models are, the more attractive they seem to be, and that is exactly what is most risky: the attractiveness of fully detailed models. They may show a lot of useful data, but they may also hide imperfections of reality!

At this moment (June 2006) the technology is there to create any possible virtual environment, based on fantasy or historic reconstruction. Today we are very much used to dazzling virtual environments in computer games that look increasingly realistic and can be augmented with any extra features, though representing daylight still seems to be the biggest problem!

Eiteljorg tells us that ‘The use of computer images of ancient monuments provides scholars with a double-edged sword. We can present more compelling and believable images than ever before, and we need few artistic skills to do so. On the other hand, the images can be so compelling that even rather sophisticated viewers may accept uncritically the information presented’ [Eiteljorg]. He ends his argument with the statement that we have to choose between attractive images or good information. In other words, it appears to be difficult to know for sure how much of the virtual representation is true and how much is guessed.

In this sense, the Digicult report 2004, Technology Watch, some conclusions about visualization of historic buildings are: ‘A bad image takes a thousand words to explain. Where a good image can save time and effort, a bad image can be confusing or misleading. For this reason, data visualization methods must be considered very carefully with particular attention to the anticipated audience and the meaning the visualization is intended to convey. When the methods and/or data used are not of good quality, the results produced by visualization may be misleading and may form false notion among users. The choice of appropriate methods and data analysis techniques requires not only training but also a great deal of common sense and experience.’ [Digicult 2004]

There are many examples on the Internet of highly detailed monuments such as churches, castles, townhouses etc. The level of detail used in them is in most cases unattainable to apply to complete cities, but serves its purpose for smaller projects that rely on much detail and realistic effects. Examples from the early computer graphics age are the detailed reconstructions of the Abbey of Cluny in France [Cluny 1994]. Because of the specific use of realistic rendering the older appearances of the Abbey could be tested and compared with alternative images.

2 - The problem of visualizing time and urban transformation

The existing or lost city increasingly attracts the attention of archaeologists, architects and architectural historians. In order to tackle the complexity of the townscape one needs to focus on the research of the transformation of its spatial structure. This being the case, we need to



Fig. 7. Reconstruction of Abbey of Cluny: early research to its former appearance.

know how the process of change and continuation of the townscape can be represented and made understandable by means of visualization techniques. In connection with this, the question needs to be answered what kind of and how much visual information is necessary for computer models of a town to provide a basis for interpreting the changes over time. To study the transformation of the architecture of an existing city means to work with imperfect, heterogeneous, sometimes disputable and often incomplete sources.

Experiments over the last twenty years have basically used two types of visualizations of time: Vertical time lines or snap shots of an area or building in different periods in time. Some examples are given further in this article. The use of time series is not new as we have seen in the work of Gordon Cullen and perspective projections showing an area in different periods of time.

Animation has long been regarded the ultimate way to show change in the urban environment, but it also often confuses because of the continuous flow there is no time to reflect. However, even if it is fun to look at, the images continue in fast order and in such a quick sequence that the earlier content of the images is soon forgotten: that's the way our memory works: despite the claims of forgotten collective memory new images replace old ones at a vast rate. Changes appear often difficult to distinguish and to remember just as the torn down monuments that are replaced by new constructions.

An early study was the 3D reconstruction of the development of Heusden between 1900 – 1990 in six phases [Alkhoven 1993; 1998, 2003]. Heusden was founded near a castle probably in the 13th century. It was fortified at the end of the 16th and again at the beginning of the 17th centuries by a fortification system which was modern for its time. During the Dutch Golden Age (17th century) it was a famous garrison town. Heusden, which had been part of the province of Holland from 1357, became part of the much poorer province of Brabant in 1813. After the fortifications had been dismantled in 1816, prosperity declined due to economic factors and the definitive departure of the garrison in 1879. In 1904 the old Town Harbor was filled in and turned into public gardens. Towards the end of World War II, part of the town was destroyed, including the Town Hall and part of the Church. During the reconstruction period after the war (1945-1965), a new town hall and a number of council houses were built.

Modernist plans in the sixties to level the fortifications and to build multi-story apartment blocks on the outskirts of town were never realized. Instead, a radical restoration plan (Development Plan) was adopted in 1965, involving repair of the fortifications, reconstruction of the historical street structure and restoration and reconstruction of buildings. The Town Harbor was re-excavated. During this restoration and reconstruction, an old map by Joan Blaeu (1649) played an important role for the realization of the reconstructed 17th-century image of



Fig. 8. Detailed drawings, maps and plans as sources for the 3D computer model.

Heusden. While the restoration had not yet been finished, Heusden was officially given the status of Protected Townscape in 1972. The restoration campaign was finished around 1990.

A simple overlay method for comparing different period in time appeared very difficult for 3D volumes.

Three-dimensional computer models representing six significant periods in the 20th century: 1900, 1943, 1946, 1965, 1975, and 1990 appeared to be a more attainable goal with the then available technology. From each of these reference dates the changes in the ground plan, the building masses and the façades were visualized. The purpose to make these models was to detect changes in masses and architectural detailing in the cityscape from 1900 to 1990. The model was based on a complete set of detailed drawings and maps from 1943, drawn just before its destruction during the Second World War. Colors were not used in a realistic way, but they served to distinguish between buildings in brick and plastered buildings. Obviously, this kind of abstraction of features can be an advantage to detect behavioral patterns or developments. These models served as scientific tools in architectural research.

These computer images were needed to be able to analyze, among other things, the approaches to restoration. The volumes of the houses were modeled as simply as possible in order to be able to enhance recognition Dormers, chimneys, porches, and other three-dimensional objects were therefore absent in these computer models. Back in 1993 when these models were created, computer storage space and bandwidth was still severely limited. Careful decisions were taken for each step in the process: the plan, parcels, houses, facades and details, even street furniture, trees and gardens.

Another relatively early project was carried out by CASA (Centre for Advanced Spatial Analysis), Bath, UK, a research-group that creates 3D cities and writes about their experiences[Bath...]. The 3D model of *Bath* is one of them. This project was supported by Bath City Council and since its completion the model has been used to test the visual impact of a number of proposed developments on the city. The model comprises over 150 urban blocks which are available as a database of three dimensional information for those involved in designing new buildings in the city.

But, most of these models only show one period in time – often the present, while the factor time complicates the organization of a 3D model's information significantly.

Arnhem3D is a current project that aims to visualize old Arnhem as it looked before the town was destroyed in World War II [www arnhem3D.nl]. The finished result will enable users to reclaim some of the cities' destroyed cultural past. Washington University, St.Louis lets you take a journey through time on the streets of downtown St. Louis in their virtual reality model [.....]. The project utilizes interactive web technologies to explore the history of the City of St. Louis



Fig. 9. Heusden: View on Town Hall 1943



Fig. 10. Heusden: View on Town Hall 1990.

and region. Currently only the 1850s and the 1950s decades are active. The Virtual City will grow richer in detail as the project is expanded in time and space.

These space-time models have in common that they are built from simple blocks with textured facades and time frames have been set up separately.

Bologna

The *NUME-project (New Electronic Museum)* aimed much higher: to realize a virtual historic museum of the City of Bologna, Italy: a 4-dimensional city that represents the urban development of the central area of Bologna from the 13th to the 20th century [Nume]. The idea is to realize a link between the concept of culture and technological innovation by creating a venue as a cultural, scientific and technological meeting point that has a function as a game and shows the cities collective memory. The four-dimensional city with its three spatial dimensions and one of time enables visitors to select a historical period for their electronic walk through the city. Multiple historic resources have been used for building the models: maps such as the Vatican fresco were analyzed in detail in order to extract useful and correct information about the buildings. The book: *Libri Terminorum* dating from 1294 contained much useful information about the community at that time, such as the ground markers that could be compared with those that are still there.

A precise digital terrain model was made as a basis for controlling all other data. Only information that was sure was visualized, those elements about which there was little or no conclusive visual information, were left out or rendered transparent.

From a human perspective the models of Bologna do not look very realistic. There is no feeling whatsoever of *immersion* that improves the way people can relate to the image or accept the image as a graphical replica. Obviously, the eye needs something more to be emotionally moved.

Highly detailed monuments can usually transport this feeling much better. They work on the senses that create feelings of admiration and inspiration. But this level of detail is unattainable and impossible to apply to complete cities, but serve its purpose for smaller projects that rely on much detail and realistic effects. The newest technology is capable of capturing the most intricate colors and details, that can be transported to 3D models.

Interesting are new developments such as ECAI Electronic Cultural Atlas Initiative. The Cultural Atlas is designed to be a tool for visualizing and analyzing historical and cultural phenomena. With the capacity to create customized maps based on a theme, era and region of interest, you can quickly answer--or at least frame--questions that would once have taken a lifetime. The ECAI digital atlas is a global collection of hundreds of networked digital



Fig. 11. Change Vismarkt Heusden 1900-1943-1990.



Fig. 12. NuMe: Bologna

humanities projects linked by a clearing house and visualized through a GIS server. [Digicult 2004] Making use of TimeMap software it is possible to find objects or events when defined in time and location. Geo-referencing, as this process is called could also play an important role in 3D visualization and combining other kinds of data.

Other time-related research is being done by extending the conventional GIS to Historic GIS (HISGIS) which can be enhanced by introducing the third dimension of objects as well.

There are also new techniques available to digitally capture information of the terrain and buildings by remote sensing, data capture methods such as photogrammetry and 3D laser scanning. With terrestrial laser scanning measurements can directly be digitally captured from the object by multiple camera views. These can be combined while elements that were not there any more can be given another color and rendered transparent. These methods appear very useful for capturing data from (partly) existing edifices, but fail where buildings are completely destroyed, when data is missing or data turns out to be uncertain. In those cases we need to consult other visual and documentary sources for verification and make reconstructions by hand, i.e. by means of input of vectors: points and lines.

This was done for the models of Utrecht Cathedral created by Derode3D that display an advanced level of detail. Each of these models exists of many polygons, shapes and colors. Light sources, texture mapping, radiosity and other rendering techniques make it look very real.

These images are really attractive. Jan de Rode from DeRoDe3D thinks that the creator of virtual heritage needs to be a designer, but also a narrator since without a compelling narrative images of virtual heritage do not mean much.

Conclusions

3D visualizations always show an interpretation, without reaching for realism. Documentation of choices for 3D modeling is pre requisite for scientific research because these images will lead their own life and others will base their research upon these images.

The examples in this article have shown that abstraction can add an extra quality instead of losing information. Abstraction definitely makes the invisible visible and makes patterns apparent.

Only those virtual heritage projects that involve themselves in the art of storytelling in addition to the 3D models of history will get enough credits to be noted by a wide audience and receive sufficient attention to justify the effort. Narratives can also be the missing link between the (still failing) technology in presenting understandable time lines and changes in the virtual environments.

So what could be the most effective images? What are the images that are functional *as well as* attractive, inspiring, amazing, stimulating and challenging? The examples just show that the solutions can obviously take a variety of forms.

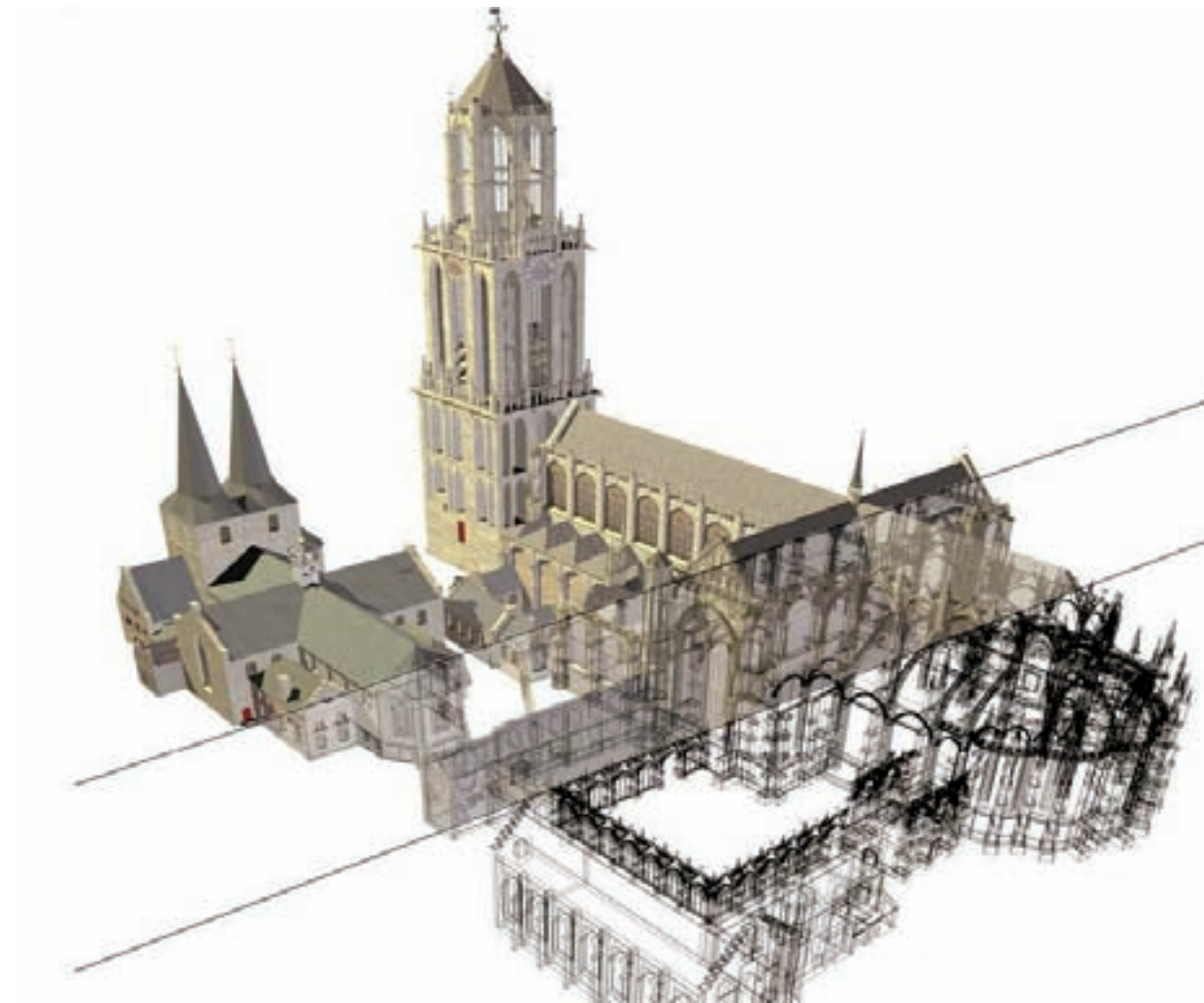


Fig. 13. Visualization of Dom Church in Utrecht, The Netherlands, by DeRode3D. The parts in wireframe have been destroyed.

Selected literature:

- [1.] P. Alkhoven, “*The Changing Image of the City. A Study of the Transformation of the Townscape by means of Computer-Aided-Architectural-Design and Visualization Techniques. A case study: Heusden*”. Canaletto, Alphen aan den Rijn 1993.
- [2.] P. Alkhoven, “*Computer Visualization as a tool in Architectural Historical Research*” in: *Architectural and Urban Simulation Techniques in Research and Education*, (Keynote address to the Third Conference of the European Architectural Endoscopy Association,) Delft University Press, 1998, 16-23
- [3.] Alkhoven, Patricia, “*Maps and 3D reconstructions of cities. From maps to virtual representations of cities*”. International Conference on the History of Cartography, 17 June 2003 Harvard University, Cambridge Massachusetts, USA.
- [4.] Alkhoven, Patricia, “*3D Reconstructions of Cities. From map to virtual representations of cities*”, GIM International The Global Magazine for Geomatics, October 2005, Volume 19, issue 10, 84-87
- [5.] Alkhoven, Patricia, “*Is it Real or is it Virtual? Digital Facsimile Maps and Atlases in the Netherlands: Part Two*”, in: *Journal of Map & Geography Libraries* , Vol. 2 (1) 2005, 5-36
- [6.] Bakker, Geeske, Frans Meulenber, Jan de Rode: “*Truth and credibility as a double ambition: reconstruction of the built past, experiences and dilemma’s*”. *Journal of Visualization and Computer Animation* 14(3): 159-167 (2003)
- [7.] Bocchi, F., M.E. Bonfigli, L. Calori, A. Guidazzoli, M. Petrone., ‘*4D Bologna Virtual Environment. The Nu.M.E. “Project State of the Art”*’, <<http://www.cineca.it/editions/ssc2001/213.pdf>>
- [8.] CAAD Futures 1997 / 1999 / 2001 papers
- [9.] Choisy, Auguste, « *Histoire de l’Architecture* », Paris 1899
- [10.] Cluny ou la gloire retrouve... IBM video 1993
- [11.] G. Cullen, “*Townscape*”, London 1961
- [12.] Digicult Technology Watch Report, December 2004. “*Visualization of Data*”, www.digicult.info.
- [13.] Drexler, Arthur, (ed), “*The Architecture of the Ecole des Beaux-Arts*”, London 1977.
- [14.] Durand, Jean Nicolas Louis, « *Recueil et parallèle des edifice de tot genre* », Paris, 1800.
- [15.] ECAADe 1999, theme 3 Modelling and City Planning
- [16.] Eiteljorg, Harrison II, ‘*The Compelling Computer Image - a double-edged sword tells us that*. Internet Archaeology URL:<http://intarch.ac.uk/journal/issue8/eiteljorg_index.html>
- [17.] Staley, David J., “*Computers, Visualization, and History: How New Technology Will Transform Our Understanding of the Past*”. Armonk: Sharpe, 2003
- [18.] Tufte, Edward, “*The visual display of quantitative information*”, 1983.
- [19.] Voigt, Andreas, Walchhofer, H.P. and Linzer, H. , ‘*The Historico-cultural Past as Spatial-related Cognition Archives: Computer-assisted Methods in the History of Urban Development, Archeology and History of Art*’, *Architectural Computing from Turing to 2000* [eCAADe Conference Proceedings / Liverpool 1999, pp. 672-677

CASA papers:

- [20.] <<http://www.casa.ucl.ac.uk/3dcities/index.htm>>
- [21.] M. Batty & Paul M Torrens, "*Modeling Complexity: The Limits to Prediction*", <<http://www.casa.ucl.ac.uk/paper36.pdf>>
- [22.] S. Evans & Andrew Hudson-Smith, "*Information Rich 3D Computer Modelling of Urban Environments*".
- [23.] M. Batty et al, "*Visualizing the City: Communicating Urban Design to Planners and Decision-Makers*".
- [24.] M. Batty et al., "*Modelling Virtual Urban Environments*"
- [25.] M.Dodge, Andy Smith & Simon Doyle, "*Virtual Cities on the World Wide Web. Towards a Virtual City Information System*"
- [26.] V. Bourdakis, "*The Future of VRML on Large Urban Models*"

URL's

- [27.] Heusden, Netherlands: <http://www.library.uu.nl/digiarchief/dip/diss/01754573/inhoud.htm>
- [28.] Arnhem, Netherlands: <http://www.arnhem3d.nl/pilot/animatie/pilot.html>
- [29.] Casa/Bath, UK: <http://www.bath.ac.uk/casa/>
- [30.] St. Louis, US, <http://www.umsl.edu/~virtu/phase2/ind.html>
- [31.] Dom ChurchUtrecht, Netherlands: *DeRode3D*: <http://www.derode3d.nl>
- [32.] NUME Italy: <http://www.cineca.it/editions/ssc2001/213.pdf>
- [33.] Jerusalem: www.jerusalem.muni.il/technun/model/
- [34.] ECAI: www.ecai.org

C.V.

Patricia Alkhoven (1962) studied Art and Architectural History at the University of Leyden, the Netherlands. In 1993 she took her PhD degree at Utrecht University with a dissertation on the application of computer-aided-design and visualization techniques in architectural historical research: "The Changing Image of the City". A Post-doctoral Fellowship from the European Commission "Human Capital and Mobility" 1993-1994 enabled her to work for seven months at the University of Strathclyde, Glasgow, UK. From 1994 Patricia Alkhoven held a position as deputy head of the Library Research Department, and, since 2000, as Project manager in the Research & Development Department in the Koninklijke Bibliotheek, the National Library of the Netherlands. She co-ordinated digitization projects in the Koninklijke Bibliotheek, organized (inter)national conferences and she was involved in several projects regarding the conservation and presentation of library collections via the Internet. She teaches and lectures on a regular basis on subjects regarding representation in art and architecture, cartography, application of computer visualization techniques, digitization and online presentation of collections. Currently (since February 2006) she is Director of UDC Consortium (Universal Decimal Classification).

Relevé et multi-représentations du patrimoine architectural

Méthodes, formalismes et outils pour l'observation dimensionnée d'édifices

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Cet article présente un ensemble de réflexions et développements autour de la définition d'une approche intégrée de restitution tridimensionnelle d'édifices patrimoniaux. Les apports principaux de ce travail concernent l'acquisition et le traitement des données relatives à la mesure de l'édifice, la formalisation des connaissances applicables à la restitution de sa morphologie et la structuration des représentations multiples autour de son modèle de description. Trois problèmes principaux seront abordés : le relevé de l'objet d'étude, la construction de son modèle géométrique et enfin de son enrichissement sémantique. Conformément aux phases de l'approche définie, l'article est organisé autour de trois dimensions principales : la fusion des données relevées par balayage laser 3D et photogrammétrie, l'étude et la formalisation de la nature géométrique des éléments architecturaux, la structuration sémantique de la maquette de l'édifice pour permettre une organisation efficace des représentations produites. Chacun de ces aspects est abordé par la définition de méthodes, l'élaboration de formalismes et des développements informatiques. Un échantillon (un module de façade) d'un édifice emblématique d'architecture classique, le «Convento della Carità» de Andrea Palladio à Venise, servira de terrain d'expérimentation.

Mots clés

Architecture, patrimoine, relevé, modélisation géométrique, description sémantique.

Catégories

D.2.11,E.1, H.4.m, J. 5

1 - Introduction

L'acquisition, le traitement et le rendu d'informations métriques concernant le patrimoine bâti a connu, durant ces dernières années, un progrès significatif grâce à l'introduction de nouveaux dispositifs de mesure comme le scanner 3D (*cf.* [1]) et à l'exploitation de techniques émergentes de restitution photogrammétrique comme la photomodélisation (*cf.* [2]). Par contre, si certains de ces outils et techniques fournissent un degré d'automatisation de plus en plus important, beaucoup de problèmes restent ouverts si l'on essaie d'évaluer leur efficacité par rapport aux exigences qu'une représentation architecturale requiert. Dans le relevé, les résultats obtenus par les procédures de reconstruction automatiques consistent essentiellement en une interpolation géométrique de données métriques (*cf.* [3]). En revanche, l'objectif d'une représentation en architecture est de conduire une lecture sémantique des données relevées au travers d'une interprétation géométrique de la forme qu'elles décrivent. Cela veut dire que pour être conforme aux objectifs d'une représentation architecturale, le processus de restitution tridimensionnelle d'une réalité observée doit nécessairement faire référence à un univers de connaissances. Il est donc nécessaire de réaffirmer la distinction historique entre une phase d'acquisition et une phase d'interprétation des données (*cf.* [4]) tout en tenant compte des relations de dépendance qui existent entre ces deux étapes. Pour donner un exemple, bon nombre d'édifices patrimoniaux témoignent de l'utilisation intensive faite par leurs bâtisseurs de la notion de mouluration. L'importance de cette notion est, pour la théorie architecturale, largement établie : elle y est décrite d'abord comme un outil essentiel dans la composition des formes, mais également comme le moyen par lequel la forme prend sens, par lequel la forme ajoute à ses propriétés géométriques des propriétés d'expression sensible - adoucissement, soulignement, etc. Dans ce sens, la mise en cohérence des procédures de traitements numériques par rapport aux codes de la représentation architecturale constitue le problème important que nous nous adressons. De plus, la phase de relevé n'est que la première étape du long processus qui caractérise l'élaboration des documents décrivant l'état actuel d'un édifice. Différents traitements visent en effet, non seulement à collecter et à organiser les informations mais surtout à produire de la documentation pour différentes analyses spécifiques. Dans ce sens, il est important de s'intéresser aux conditions au travers desquelles des représentations multiples produites à partir du relevé peuvent être organisées autour d'un modèle de description de l'édifice. Cela impose, à partir d'une description sémantique de l'objet, d'isoler une structure d'entités dont les représentations sont organisées en fonction de plusieurs points de vue. Cet article est organisé comme suit : la section 2 présente les principaux apports méthodologiques de l'approche de reconstruction 3D développée : depuis le relevé jusqu'à la représentation de l'édifice en fonction d'un point de vue, c'est-à-dire d'une exigence d'analyse. Enfin, la section 3 termine l'article avec des réflexions conclusives et des perspectives de recherche.

2 - Une approche hybride pour la reconstruction 3D d'édifices

Pour la phase de reconstruction tridimensionnelle à partir d'un relevé, la plupart des projets de documentation d'objets culturels emploient une technique ou une autre, tandis que seulement un petit nombre d'expériences utilisent une combinaison de techniques. Mais, au delà de l'application d'un procédé technique, qu'il soit simple ou intégré, d'autres dimensions d'ordre méthodologique s'imposent pour la détermination d'une stratégie d'acquisition et de traitement des données spatiales. Une première contribution de notre travail a consisté en une classification des approches actuelles de reconstruction 3D d'édifices patrimoniaux s'appuyant sur l'étude des exigences de description qui les déterminent et en présentant de façon transversale les procédés techniques que les auteurs ont mis en place pour leur développement. En effet, le choix d'un type de représentation véhicule les modalités de collecte de données et détermine leur traitement. Dans cette optique, nous regroupons un certain nombre d'expériences en quatre catégories d'approches principales : celles qui visent à l'exactitude géométrique du modèle 3D (cf. [5]) ; celles qui sont basées sur des exigences de description spécifiques à un type d'analyse (cf. [6]) ; celles qui se concentrent sur la restitution de l'apparence visuelle (cf. [7]) ; celles qui focalisent sur la représentation de plusieurs aspects à la fois (cf. [8]).

L'analyse de ces expériences nous a permis d'isoler quatre préoccupations distinctes pour la définition d'une approche de restitution d'objets architecturaux que nous présentons ici de façon succincte¹.

- Pour l'étape de **relevé**, la prise en compte d'une stratégie d'intégration des moyens actuels d'acquisition de données 3D (balayage laser et photogrammétrie multi-vues) afin de définir leur niveau d'adaptation au problème du relevé architectural.
- Pour l'étape de **modélisation géométrique**, la nécessité d'isoler de l'observation de l'objet la nature géométrique des éléments qui le composent et de définir des procédures appropriées pour leur reconstruction. Dans le cas spécifique des éléments typés (bases, chapiteaux, moulures, etc.) il s'agit entre autres, à partir d'une analyse des traités d'architecture, d'en extraire des règles, de les formaliser et d'en faire une traduction numérique exploitable dans le but de conduire la modélisation par une procédure d'instanciation de primitives architecturales.
- Pour l'étape d'**enrichissement de la maquette**, l'introduction de la notion d'*objectif d'exploitation* ou de *point de vue* qui conditionne les choix entre différentes représentations de l'objet. Le modèle géométrique associé à l'objet architectural doit alors être capable de supporter plusieurs représentations de l'objet (modèles multi-représentations).
- Pour l'étape d'**exploitation de la maquette numérique** produite, la structuration en parties et sous parties du modèle de l'objet architectural et l'identification de leurs relations

Note 1. Pour une description détaillée de l'approche de reconstruction 3D le lecteur pourra consulter ces publications (cf. [9],[10])

réciproques pour garantir la cohérence des informations produites au cours du processus de restitution.

Pour chaque phase ci-dessus décrite, l'approche développée introduit et exploite les connaissances architecturales comme support pour l'interprétation et la restitution des formes. En combinant les techniques de balayage laser et de modélisation basées sur l'image, le processus de reconstruction des surfaces utilise d'un côté les nuages de points pour extraire des profils significatifs et pour créer des polyèdres triangulés et de l'autre côté, les photographies numériques pour couvrir les zones d'ombre du nuage de points, pour collecter des coordonnées additionnelles et pour extraire des textures. Dans les paragraphes qui suivent, les phases principales de cette approche sont décrites.

2.1 Consolidation hybride de différentes sources

La collecte de données dimensionnelles d'un objet architectural nécessite en général un nombre très important de relevés. Même en utilisant différents dispositifs d'acquisition à la fois, il est rare d'arriver à collecter une quantité d'informations satisfaisantes pour plusieurs exploitations dans une seule campagne. Un problème important est alors celui de concevoir un système capable d'intégrer des acquisitions provenant de différents dispositifs et éventuellement effectués à des moments différents. Dans ce sens, on s'est concentré sur l'identification d'une stratégie d'acquisition exhaustive qui prend en compte non seulement la complexité géométrique et la variété d'éléments de l'édifice étudié, mais aussi un ensemble de modalités d'extraction d'informations nécessaires pour l'élaboration de représentations multiples. Plus précisément il s'agit d'une méthode d'acquisition conjointe (par scanneur laser et photo numérique) et de la fusion des données résultantes. La fusion de données est basée sur une méthode de recalage 2D/3D, c'est-à-dire la mise en place d'une image par rapport à un objet 3D (voir Fig. 1). L'algorithme implémenté (cf. [11]) permet (à partir de la sélection de 11 points homologues 2D/3D) d'estimer la matrice de projection de la caméra (position et orientation de l'appareil photo au moment de la prise de vue) dans l'espace 3D (voir Fig. 2).

L'exploitation des résultats de cette intégration a concerné trois aspects :

- La possibilité d'ajouter au relevé laser 3D des acquisitions photographiques (effectuées en campagnes de relevé successives, ainsi que de pouvoir exploiter des images de campagnes précédentes) ;
- L'extraction des coordonnées additionnelles pour couvrir les zones d'ombre du nuage de points ;



Fig.1. L'orientation d'une photographie sur le nuage de points

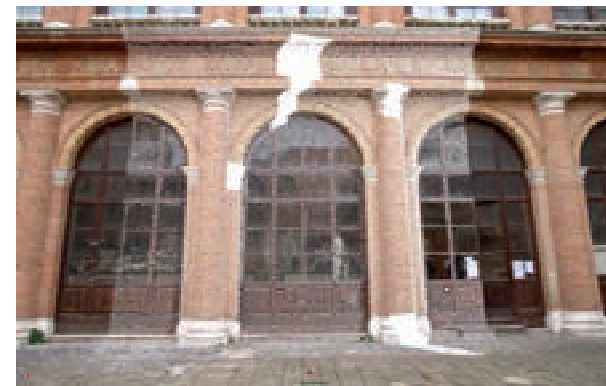


Fig.2. Superposition photographie/nuage de points

- La possibilité d'ajouter un support visuel (image), superposé au support métrique (nuage de points) pour l'interprétation des formes.

Les trois aspects ci-dessus présentés caractérisent un outil que nous avons conçu pour l'extraction de profils s'appuyant à la fois sur l'image et sur le nuage de points. Cet outil utilise un plan d'intersection dans le nuage de points qui est également exploité comme plan de rectification d'image. Un réseau de nœuds (programmée en langage MEL²) permet de manipuler le plan en intersection avec le nuage de points en déterminant une mise à jour en temps réel du redressement de la photographie (voir Fig. 3).



2.2 L'étude et la formalisation de la nature géométrique des éléments architecturaux

En ce qui concerne la phase de restitution de la morphologie de l'édifice, notre démarche s'appuie sur un constat : la représentation analytique d'un objet d'architecture doit s'appuyer sur l'interprétation des éléments qui le composent au travers l'exploitation de connaissances spécifiques. Pour donner un exemple on peut citer la représentation géométrique du fût d'une colonne. Cet élément, loin d'être un simple cylindre, est caractérisé par une *allure* (tronconique, galbé du bas, galbé du tiers, ou renflée) et des transitions comme l'*apophyge* (moulure adoucissant la rencontre du fût avec la base ou avec le chapiteau) ou l'*astragale* (corps de moulures séparant le chapiteau du fût) (cf. [12]). Ce type d'observation intéresse la quasi totalité des parties d'un édifice. Dans les cas, peu fréquents, où la géométrie de l'objet est plus complexe (décors, sculptures, etc.) ou échappe à une lecture sémantique, on utilisera les techniques de reconstruction par maillage automatique des surfaces (cf. [13]). À partir d'une analyse géométrique des différentes parties d'un édifice et en ayant comme objectif sa description

Note 2. MEL : Maya Embedded Language

Fig. 3. L'extraction des profils sur un support mixte : plan d'intersection/rectification

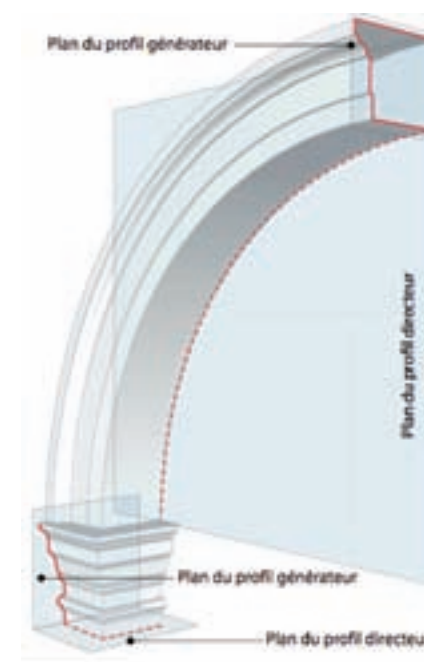


Fig. 4. Les plans de construction utilisés pour l'extraction des profils caractéristiques des formes architecturales

sémantique, notre travail s'est concentré sur la définition d'une méthode pour la reconstruction géométrique à partir de profils. Cette méthode est fondée sur l'analyse des invariants et des spécificités morphologiques que l'on peut extraire d'un découpage sémantique du bâti. Pour chaque catégorie d'éléments, nous identifions les informations pertinentes à sa description géométrique, la technique la plus adaptée à leur extraction et une chaîne de procédures pour la génération des surfaces. La démarche de restitution est organisée autour de quatre notions générales : la surface dominante, la transition, le plan de construction (voir Fig. 4) et la répétition. La restitution de la forme architecturale est alors conduite par l'identification du processus permettant sa construction géométrique. En effet, l'utilisation du dessin va au-delà du simple travail de transcription passive d'une réalité donnée car le dessin en architecture est avant tout un outil d'analyse, de conceptualisation et finalement de projection (cf. [14]). L'étude de la forme a donc une double finalité : la première est celle qui conduit à la représentation, la seconde est celle qui conduit au relevé de l'objet. Le relevé peut être vu comme un processus inverse dans lequel, à partir d'un objet existant, on reconstruit les étapes nécessaires à sa réalisation et on interprète l'idée de conception qui est en amont de sa réalisation (cf. [15]). Or, une démarche de ce type ne peut être conduite qu'en faisant référence aux systèmes descriptifs et de représentation qui ont présidé à la conception de la forme. Pour l'étude des éléments du patrimoine bâti, il est donc nécessaire de faire appel aux traités d'architecture qui capitalisent les savoirs relatifs à l'art de bâtir ainsi qu'aux systèmes de représentation en différentes périodes historiques.

2.2.1 Un formalisme générique pour la description d'éléments moulurés

Dans le but d'approfondir cette thématique une expérimentation sur la formalisation des éléments moulurés du langage classique a été menée. Ce courant stylistique a fait l'objet de nombreuses théorisations développées à partir du quinzième siècle et constitue un exemple emblématique de la relation entre géométrie et architecture. La première phase de notre analyse a consisté en l'identification des éléments géométriques primitifs exploitables en combinaisons mécaniques pour la construction des moulures : les *atomes géométriques* (voir Fig. 5). Il s'agit d'un ensemble fini de primitives géométriques permettant de reproduire par combinaison toute moulure du langage classique de la classification de Rattner (cf. [16]).



Fig. 5. Atomes géométriques pour la construction géométrique des moulures du langage classique

Ces atomes sont les seules entités de la formalisation pour lesquelles nous fournissons une information géométrique (points de contrôle de segments ou d'arcs). La génération de la surface entière de l'élément s'appuie ensuite exclusivement sur la formalisation de contraintes entre ces atomes et sur des fonctions de modélisation géométrique. Une difficulté a du être surmontée à ce propos : la structuration des entités dans une description géométrique de la forme est strictement subordonnée aux fonctions de modélisation tridimensionnelle (révolution, extrusion, etc.). Or, le découpage de la forme résultant des exigences de modélisation géométrique ne coïncide pas forcément avec celui de sa description sémantique. Un terme architectural peut par exemple identifier une partie de l'objet dont les surfaces sont générées à partir de deux procédures de modélisation distinctes. Pour résoudre ce problème la formalisation de l'élément est alors conduite en fonction des relations entre deux niveaux parallèles de description : géométrique et sémantique. Le premier permet de reconstruire la forme en trois dimensions, le second permet d'organiser ses parties en fonction du vocabulaire de l'architecte.

Le niveau de description géométrique s'appuie sur les relations entre quatre types de nœuds qui décrivent la construction de l'élément, de la définition de ses atomes géométriques jusqu'à la génération complète du volume : *atomes géométriques* (voir Fig. 6), *profils* (voir Fig. 7), *surfaces* (voir Fig. 8). La figure 9 fournit un exemple de formalisation géométrique d'un chapiteau dorique à partir de l'interprétation du traité de Palladio (cf. [17]).

La démarche conçue s'appuie sur l'élaboration d'un réseau de *nœuds* toujours développés en langage MEL. Un *nœud* est une structure qui peut organiser, recevoir et fournir des informations au travers de ses *attributs*. Une surface, quelle que soit sa représentation géométrique (polygonale ou NURBS³), peut être enregistrée dans un nœud sous forme d'un attribut. L'interconnexion des nœuds en réseau produit le résultat final.

Le niveau de description sémantique est défini par une structure de concepts organisés autour de la description géométrique. Les nœuds de la description sémantique sont reliés d'un côté à un terme architectural, de l'autre ils regroupent les éléments de la description géométrique dans une structure hiérarchique : atomes/mouleurs/parties du profil/profil.

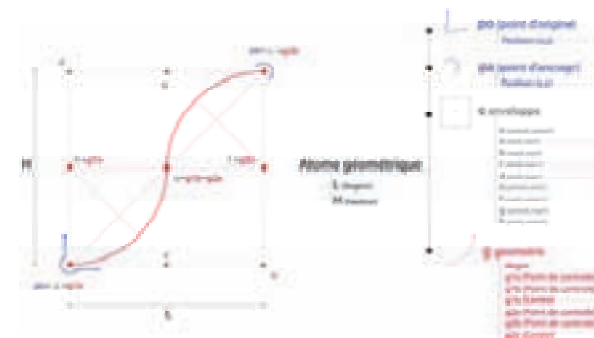


Fig. 6. Schéma des relations d'attributs d'un nœud « atome »

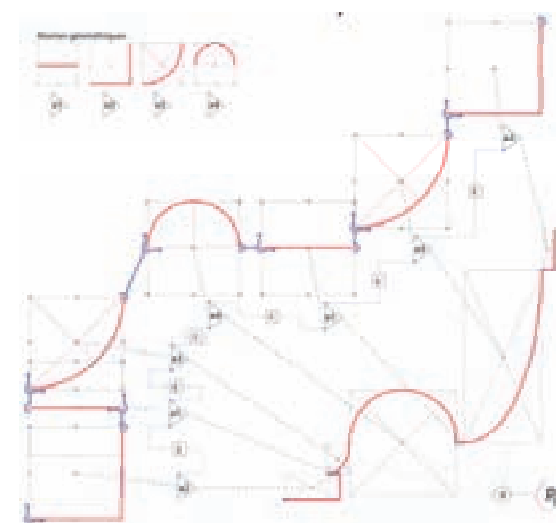


Fig. 7. Construction d'une moulure par combinaison d'atomes géométriques

Note 3. NURBS : Non Uniform Rational B-Splines

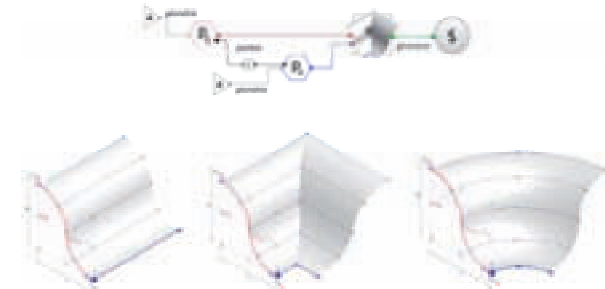
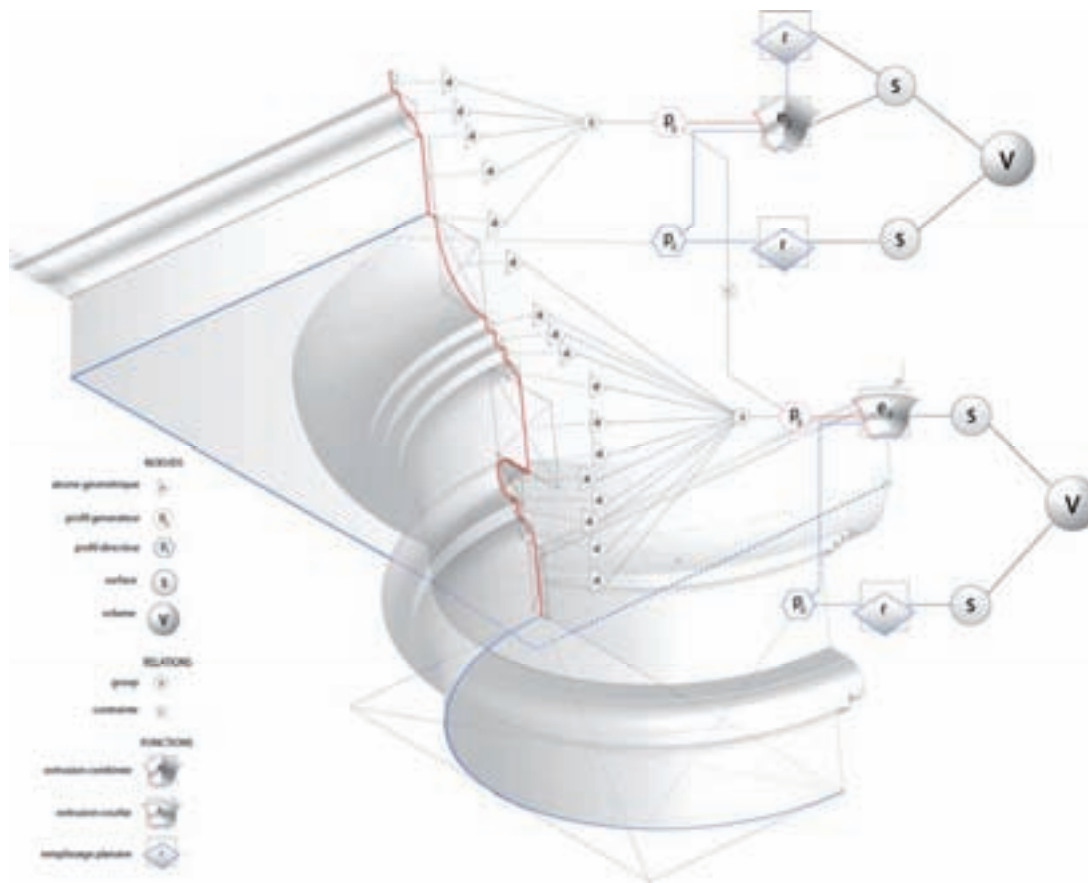


Fig. 8. Fonctions de génération de surfaces formalisées

Fig. 9. Description sémantique d'un chapiteau dorique à partir du traité de Palladio

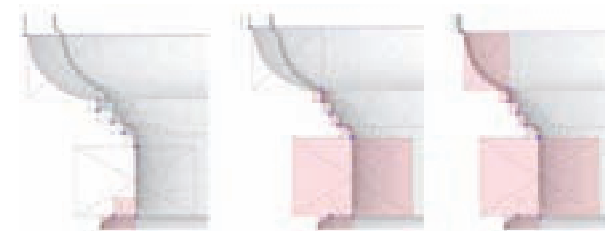


Fig. 10. Instanciation de la primitive dans le nuage de points. Déformations sous-contraintes des atomes géométriques



Fig. 11. La primitive instanciée sur une photographie orientée

2.2.2 L'extraction d'informations dimensionnelles

Dans l'approche de reconstruction développée, nous utilisons les éléments formalisés comme primitives à instancier sur le nuage de points issu d'un balayage laser 3D. Dans ce cadre, les relations établies entre les deux niveaux de description (géométrique et sémantique) sont exploitées pour extraire de la phase de relevé des informations pertinentes pour la description architecturale des éléments qui composent l'édifice. Les contraintes géométriques établies entre les différents éléments nous permettent de déformer la primitive (voir Fig. 10), sans aucune

perte de continuité entre les surfaces qui la composent, pour l'adapter finement à l'objet relevé (voir Fig.11). Le niveau de description sémantique nous permet alors d'extraire de la représentation géométrique un abaque d'informations dimensionnelles pertinentes. Par exemple, nous pouvons connaître la hauteur de l'échine du chapiteau et non pas la seule distance entre deux points du nuage.

2.3 Structuration de la maquette et multi-représentation

Le concept de forme numérique contient toutes les instances de l'objet qui peuvent être représentées en considérant qu'elles ont une nature géométrique caractérisée par leur extension spatiale (*cf.* [18]). Les éléments architectoniques ont en effet une forme (extension spatiale), ils peuvent être décrits par des structures (collections d'entités et décomposition partie-ensemble), ils ont des attributs qualitatifs (couleurs, textures, termes, etc). Cela impose avant tout de considérer l'édifice comme système de connaissances architecturales, ensuite d'en extraire un modèle de description, enfin de définir les représentations possibles de sa forme en fonction de plusieurs objectifs d'analyse.

Pour décrire un édifice, la première phase consiste alors en une décomposition morphologique en fonction d'un vocabulaire utilisé par une analyse spécifique. La figure 12 montre deux découpages du même objet élaborés en fonction de deux objectifs différents. La deuxième phase concerne la description sémantique de la morphologie de l'édifice. Pour cela on utilise une représentation symbolique, dans l'espace 3D, des relations (partie/ensemble) établies entre les éléments isolés. Il s'agit d'un graphe 3D (arborescence dans l'espace) dont la configuration dépend de la manipulation (relations hiérarchiques) d'un ensemble de termes dans une liste de termes (voir Fig.13). Nous établissons ce graphe à l'aide de nœuds : *entité morphologique*, *groupe finalisé*, *repère*.

- Une *entité morphologique*, qui résulte d'un découpage morphologique, constitue un concept identifié par l'utilisateur pour la description de l'édifice et est associée à des représentations géométriques.
- Un *groupe finalisé* regroupe des *entités morphologiques*. Son extension spatiale résulte en effet de l'union des enveloppes englobant les entités qui lui appartiennent.
- Un *repère* indique un aspect particulier à l'intérieur d'une entité. Par exemple, une moulure d'un élément ou un aspect particulier sur la surface de l'entité (personnage historique d'un bas-relief, dégradation du matériau, etc.).

La troisième phase concerne l'organisation des représentations multiples (multi-représentation) que l'on peut associer aux entités. Différentes recherches se concentrent aujourd'hui sur les

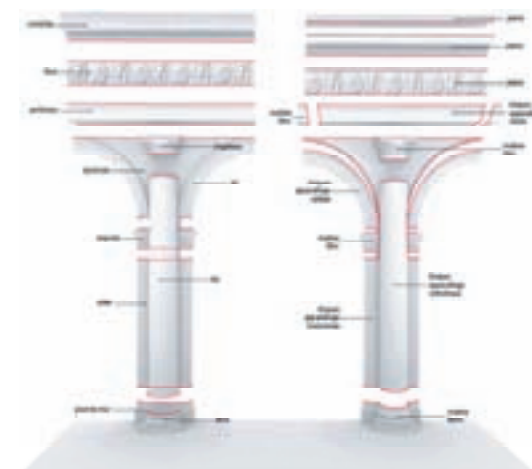


Fig. 12. Deux découpages morphologiques élaborés en fonction de deux objectifs d'analyse : le vocabulaire de l'architecte (à gauche) et les techniques de construction (à droite).

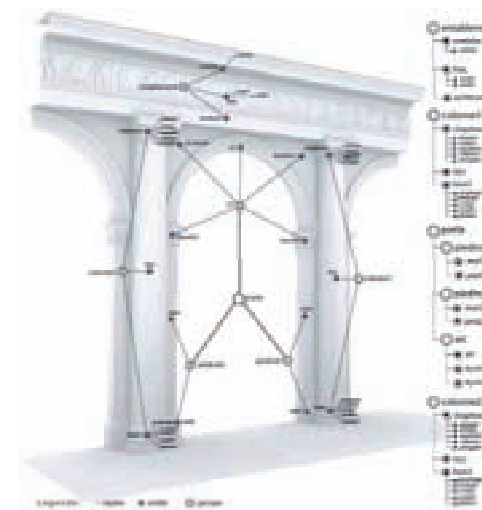


Fig. 13. Graphe de description sémantique

multi-représentations d'entités géométriques dans différents domaines : en cartographie (cf. [19]) les multi-représentations sont exploitées pour garantir un niveau d'information graphique adéquat à une échelle donnée ; en génie mécanique des multiples représentations correspondent à différents niveaux de complexité polyédrique nécessaires à différentes exploitations de la maquette numérique (cf. [20]). Ces expériences organisent plusieurs représentations du même objet en s'appuyant toujours sur la même base géométrique (vecteurs 2D ou polygones 3D). La différence parmi les multiples représentations concerne donc la quantité d'informations géométriques qu'elles contiennent.

Comme on l'a vu, l'analyse d'édifices peut se servir de techniques de représentation qui exploitent différentes bases géométriques : nuages de points, modèles filaires ou polyèdres. Il est alors indispensable d'introduire une distinction entre les notions de résolution et de représentation : une représentation résulte d'une technique d'élaboration qui permet de décrire la forme d'un objet en fonction d'une base géométrique et d'un niveau de résolution. Pour chaque type de représentation géométrique, il est alors important de comprendre le rôle qu'elle peut jouer dans la documentation de l'état actuel de l'édifice. Il s'agit d'identifier le type de description qu'elle permet, les techniques et/ou les procédures nécessaires à son élaboration et les informations qu'elle véhicule.

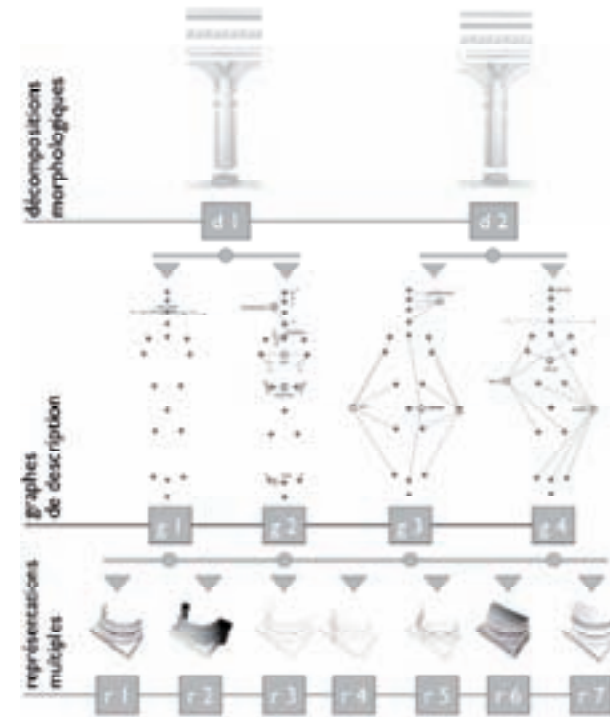
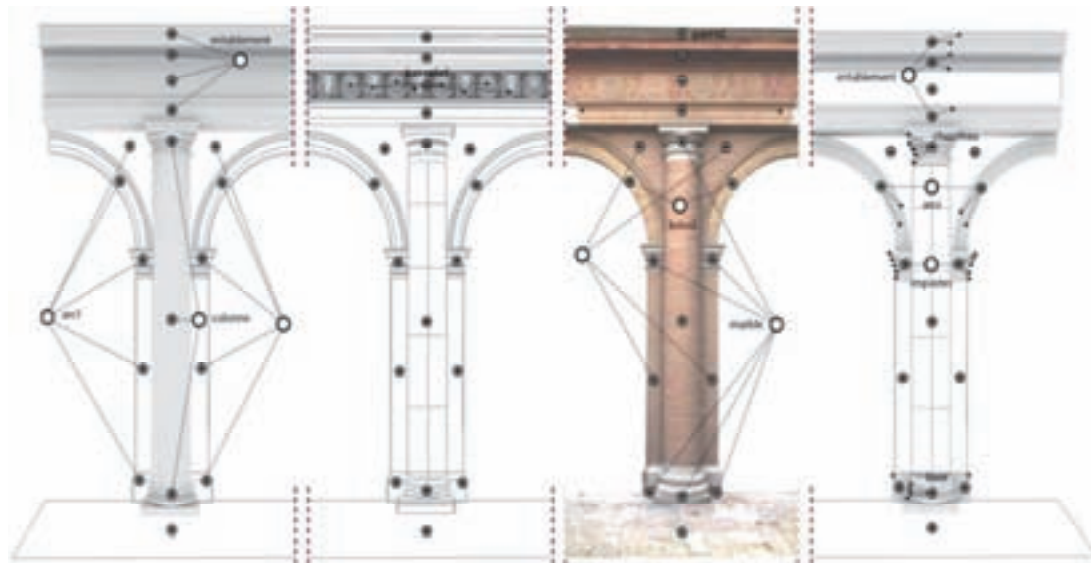


Fig. 14. La structure de description basée sur trois niveaux parallèles. Du haut vers le bas : niveau sémantique, structurel et de représentation.

Fig. 15. Quatre « points de vue » sur l'objet étudié. De gauche à droite : l'analyse de l'ordre, des bas-reliefs, des matériaux et des éléments moulurés.

La division entre trois niveaux parallèles de description (sémantique, structurel et de représentation) introduit par notre approche peut alors être exploitée pour la construction de points de vue sur l'édifice. Cela consiste en la possibilité de construire une représentation de l'édifice en fonction d'un besoin d'analyse spécifique. La logique du système est basée sur l'exigence de décliner les structures de description (voir Fig. 14) pour permettre une vraie liberté d'organisation des données. Cela offre une liberté importante dans l'exploitation des données issues du relevé, car, à partir du même modèle géométrique de la morphologie, on peut élaborer différentes descriptions sémantiques en fonction d'une exigence d'analyse. Comme nous nous intéressons principalement à la documentation graphique du patrimoine bâti, la notion de point de vue coïncide alors avec celle d'objectif de la représentation (voir Fig. 15).

3 - Conclusions

Ce travail se situe dans le cadre spécifique de l'acquisition de données dimensionnelles et de leur exploitation pour la représentation du patrimoine bâti. Pour chacune des préoccupations abordées (relevé, reconstruction, structuration, représentation) beaucoup d'efforts sont encore à faire pour que les résultats obtenus répondent aux exigences des différents domaines disciplinaires qui s'intéressent aux monuments historiques. À ce propos, l'observation conjointe des deux niveaux de formalisation parallèles (géométrique et sémantique) met en lumière un aspect que nous jugeons important : la description sémantique d'une forme est contrainte par une représentation mentale (divisions, transitions, etc.) qui n'est pas toujours suffisante pour la description exhaustive de sa morphologie. Cela justifie la démarche que nous adoptons : on ajoute une couche sémantique à une représentation géométrique. Mais cela suggère en même temps le niveau de difficulté qu'une démarche inverse peut poser.

Références bibliographiques

- [1.] W. Boehler et al., "*3D Scanning Software : an introduction*", [in] Proceedings of the CIPA WG 6 International Workshop on Scanning for Cultural Heritage Recording, Corfu 2002
- [2.] P. Debevec et al., "*Modeling and Rendering Architecture from Photographs: A hybrid geometry and image-based approach*", [in] Proceedings of SIGGRAPH 1996, pp. 11-20
- [3.] F. Remondino, "*From point cloud to surface : the modeling and visualization problem*", [in] ISPRS International Workshop on Visualization and Animation of Reality-based 3D Models, Tarasp-Vulpera, Switzerland 2003

- [4.] J.-P. Saint-Aubin, “*Le relevé et la représentation de l’Architecture*”, Inventaire Général E.L.P., Paris 1992
- [5.] G. Fangi et al., “*Fast and accurate close range 3D modelling by laser scanning system*”, [in] Proceedings of CIPA International Symposium, Surveying and Documentation of Historic Buildings, Monuments, Sites, Postdam, Germany 2001
- [6.] A. Lingua, “*Digital Photogrammetry : a standard approach to cultural heritage survey*”, [in] Proceedings of ISPRS International Workshop, Vision Techniques for digital architectural and archeological archives, Ancona, Italy 2003
- [7.] T. Abmayr et al., “*Realistic 3D reconstruction – combining laserscan data with RGB color information*”, [in] Proceedings of ISPRS International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol XXXV, Part B, Istanbul 2004, pp.198-203
- [8.] S. F. El Hakim et al., “*Effective 3D Modeling Of Heritage Sites*”, [in] Proceedings of 4th International Conference on 3-D Digital Imaging and Modeling, Banff, Canada 2003, pp. 302-309
- [9.] L. De Luca et al., “*Reverse engineering of architectural buildings based on a hybrid modeling approach*”, *Computers & Graphics*, Elsevier, April 2006, Vol. 30, n°2, pp. 160-176
- [10.] L. De Luca, “*Relevé et multi-représentation du patrimoine architectural. Définition d’une approche hybride de reconstruction 3D d’édifices*”, Thèse de Doctorat de l’Ecole Nationale Supérieure d’Arts et Métiers, CER d’Aix-en-Provence 2006
- [11.] R. Tsai, “*An efficient and accurate camera calibration technique for 3D machine vision*”, [in] Proceedings of IEEE conference on Computer Vision and Pattern Recognition, 1986
- [12.] J-M. Perouse de Montclos, “*Architecture vocabulaire. Principes d’analyse scientifique*”, Imprimerie Nationale, Paris 1972
- [13.] C. Curless, “*A Volumetric Method for Building Complex Models from Range images*”, [in] Proceedings of SIGGRAPH 1996
- [14.] J. Lichtenstein, “*La couleur éloquente*”, Flammarion, Paris 1989
- [15.] R. Migliari, / L. Docci, “*Geometria e Architettura*”, Gangemi editore, Rome 2000
- [16.] D. Rattner, “*Parallel of the classical orders of architecture*”, Acanthus Press 1998, New York 1998
- [17.] A. Palladio, “*Les quatre livres de l’Architecture*”, Edition originale : Venezia , 1570, Re-Re- édition : The four books of Architecture, Dover publications 1965
- [18.] B. Falcidieno, / M. Spagnuolo, “*A Shape-abstraction paradigm for modelling geometry and semantics*”, [in] Proceedings of International Conference on Computer Graphics, Los Alamitos 1998.
- [19.] S. Spaccapietra et al., “*GIS Databases: from Multiscale to Multirepresentation*”, [in] Proceedings of the International Workshop on Emerging Technologies for Geo-Based Applications, Ascona, Switzerland 2000
- [20.] J.-C. Léon, “*Structure d’un environnement de Conception Multi-vues et Multi-représentation*”, [in] Actes des Journées Modeleurs Géométriques, Grenoble 1997

Modélisation informationnelle : concepts fondamentaux. Visualiser pour raisonner sur des connaissances architecturales

14 règles plus une

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Pour comprendre et représenter les évolutions du bâti, question renouvelée avec le développement des NTIC, l'analyste s'appuie sur des connaissances évolutives ayant dans notre champ d'application - le patrimoine architectural - un caractère spatialisable (par l'attachement à un lieu λ) mais aussi des caractéristiques handicapantes (hétérogénéité, incertitudes et contradictions, etc.).

Nous utilisons ce caractère spatialisable pour intégrer les ressources constituant le jeu de connaissances propre à chaque édifice: connaissances a priori, sources documentaires, observations contemporaines.

Cette démarche que nous nommons modélisation informationnelle a pour objectif un gain de compréhension du lieu architectural et des informations qui lui sont associées. Notre contribution introduit les filiations de cette démarche et le cadre méthodologique qui la matérialise sous la forme d'un « jeu de règles ».

This contribution introduces basic concepts and ideas behind a renewed modelling practice that we call informative modelling. This practice is about developing for the field of the architectural heritage, graphic disposals aimed at being what J. Bertin calls “knowledge and discovery tools”.

The contribution brings up the reasons why we have come to think such practice should be identified and named, and how it can be further developed.

Although the main text is written in French, legends of figures (written in English) should give English-speaking readers a synthetic view of the contribution. Moreover, the “14 rules plus one” are translated into English so as to enable them to play their expected role: food for thinking.

1 - Introduction

Quelles que soient les traces, vestiges ou documents, dont nous disposons aujourd'hui pour le lire, le bâti (quelle qu'en soit l'échelle (voir note 1.), « de la ville au décor architectural ») témoigne par ses propres transformations de l'évolution des savoirs architecturaux, et plus largement nous renvoie une image à déchiffrer, des sociétés qui l'ont conçu, puis tour à tour embrassé, rejeté, masqué ou éclairé. Autrement dit, le bâti témoigne à la fois de sa propre histoire, de celle du lieu qu'il occupe, et enfin de celle des savoirs dont il est issu. Il n'est pas très surprenant en conséquence que son étude soit aujourd'hui encore discrétisée par disciplines. Chacune de ces disciplines, qui souvent s'ignorent, a vu naître ses propres outils et méthodes d'analyse.

Au final des jeux distincts d'informations et de connaissances sont formalisés qui le plus souvent s'appuient en priorité sur des vestiges ou documents qui forment un réseau d'indices dont une lecture critique permet de formuler un scénario plus ou moins vraisemblable sur la vie de l'objet architectural. Ces connaissances ont pourtant un point commun : le bâti et son évolution, à différentes échelles. Elles ont également des intrants communs : une documentation souvent incomplète ou incertaine complétée par le relevé d'éventuels vestiges. Elles partagent enfin un extrant « naturel » : la maquette 2D/3D. L'intégration de ces connaissances, ou du moins une meilleure compatibilité des extrants aux processus de production de ces connaissances, apparaît donc une ambition crédible.

Mais l'outil informatique, loin de déboucher sur une meilleure intégration de ces connaissances, semble avoir au contraire perpétué cette dispersion dans l'étude de l'objet architectural.

Pire, là où Andrea Palladio [1] nous transmet par la figure, à travers les siècles, à la fois l'image d'objets architecturaux qu'il relève et la connaissance qu'il en déduit ; nos outils contemporains semblent inscrire dans la durée un divorce profond entre connaissance de l'objet et représentation de l'objet. Dans le premier cas, l'analyste rassemble ses indices et les pérennise au travers de solutions dites de « gestion d'informations » (SGBDR, SIG, etc.) au sein desquelles aucun dispositif de visualisation pour l'architecture n'est disponible. Dans le deuxième cas, l'analyste produit une représentation à caractère réaliste (CAO, imagerie de synthèse, etc.) qui n'entretient le plus souvent aucun lien structurel avec la première, voire qui s'affranchit de toute étude sérieuse sur le lieu représenté.

Tout semble se passer dans ce deuxième cas comme si l'affirmation géométrique qu'impose l'outil tenait lieu de compréhension de l'objet architectural, comme si le caractère figuratif et séduisant de la représentation obtenue nous interdisait de transmettre une information de fond (voir Fig. 1). Tout semble se passer comme si la maquette devenue virtuelle pouvait soudain, comme la carte de Borgès [2] le voulait, « recouvrir le territoire ».

Note 1. La notion d'échelle à laquelle il est fait référence est celle des niveaux de conception de P. Boudon. (P. Boudon « *Richelieu ville nouvelle* » Dunod 1978)



Fig. 1. Informationally empty representation that by hiding doubts, and questions keeps secret even what is known – result of an excess of enthusiasm for the trendy technologies of 3D display (geometrical exhaustiveness, lack of justification, lack of scale, lack of information encoding)

[La restitution 3D de la ville d'Aï Khanoum, in journal CNRS, n° 178, novembre 2004, aut. TAISEI/AOROC/ENS]

Understanding the evolution of historic artefacts, may they be individual edifices or complex urban fabrics, requires a cross-examination of various sources: specific pieces of information such as archives or findings (what remains of the edifice itself today) and generic pieces of knowledge. In the field of the architectural heritage, the representation of artefacts, particularly for communication purposes, has benefited from the development of computer-based modelling techniques. But numerous experts in the above mentioned heritage field have come to question the readability of realistic models inside which the hypothetical nature of the content, a reconstruction, is not clearly assessed (see Fig. 1). In parallel, research in information visualisation has demonstrated that graphics can support reasoning as well as communication.

Pourtant la représentation architecturale a, au travers de son histoire telle que nous la connaissons, toujours été considérée à la fois comme un outil de communication et comme un moyen de raisonner.

Dans le plus ancien traité d'architecture connu, Vitruve [3] propose une catégorisation des représentations (Ichnographie, Orthographie, Scenographie) dont l'ambition est de transmettre à la façon des anciens grecs des *idées* à propos de la disposition de lieux, soulignant par là même déjà la nature abstraite du graphique.

Depuis la renaissance et l'expérience de la perspective de Brunelleschi, les traités d'architecture se succèdent à l'intérieur desquels le graphique intervient aussi bien pour penser à propos de l'objet que pour donner une image de l'objet (*cf.* F.Fichet [4] et J.P Saint-Aubin [5]), comme l'illustrent les exemples ci-contre (voire Fig. 2.).

Avec l'influence croissante des plate-formes informatiques sur la représentation architecturale durant les deux dernière décennies, les maquettes virtuelles sont devenues de plus en plus efficaces en matière de communication, posant de nouvelles questions largement débattues, souvent plutôt techniques, comme le réalisme et la gestion du temps-réel (*cf.* A. Perkins [6]), les modes de navigation (*cf.* A. Parush [7]), les modalités de représentations alternatives (*cf.* L. Kobbelt [8]), la conception (*cf.* R. Oxman [9], S.F. Qin [10]), le relevé et la restitution (*cf.* F. Ramondino [11], I. Suveg [12], L. De Luca [13]).

Mais dans le champ de l'architecture patrimoniale les objets que nous cherchons à représenter sont rarement assez bien connus pour que leurs évolutions puissent être décrites puis figurées de façon homogène. Avant qu'une restitution puisse être tentée, son auteur doit construire une hypothèse à partir de données incertaines (manuscrits, illustrations, etc.) qui le plus souvent restent incomplètes (*cf.* I. Dudek [14]) et vont à l'encontre de la pente technologique naturelle (exhaustivité géométrique, absence d'échelle, "réalisme").

Ainsi l'adoption des NTIC pour mieux comprendre, documenter et visualiser les évolutions du bâti patrimonial se heurte à une difficulté d'ordre méthodologique et technologique prépondérante - la nature même des jeux de connaissances propres au champ patrimonial. En effet, la compréhension des évolutions du bâti s'appuie sur l'analyse conjointe de connaissances spécifiques et de connaissances génériques ayant dans ce champ d'application des caractéristiques très handicapantes vis à vis des technologies actuelles de gestion d'information localisées spatialement. Dès lors l'apport attendu de l'application des NTIC à notre domaine en matière de production et surtout d'échanges de connaissances reste pour l'essentiel prospectif, si ce n'est du strict point de vue de la vulgarisation.

Quelles solutions a-t-on lorsque d'un côté on ne sait pas vraiment comment était un édifice, et de l'autre côté on dispose d'outils informatiques qui imposent l'exhaustivité et un réalisme

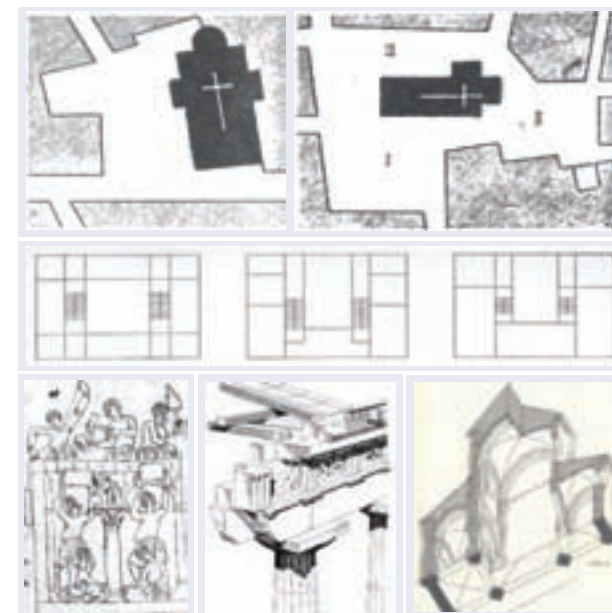


Fig. 2. Top: Sitté's urban contextualisation sketches [30]; middle: Wittkower's comparative sketches of Palladio's villas [31]; bottom, left to right: a graphic on "how to build" by Villars De Honnecourt [32], Viollet Le Duc's composition analysis and structural description of the Doric order [34]; a synthetic vision of the composition of the gothic churches in Vezelay [33].

Architectural representation has throughout its history been continuously considered as a form of reasoning and a tool for communication. In his treaty of architecture, Vitruvius proposes a three-category classification thought to communicate *ideas about the disposition of objects*, underlining the abstract nature of graphics: *they should be used in order to think about objects as well as to give an image of the objects*. During the last two decades, the growing influence of computer graphics on architectural representation made virtual models more and more efficient in communication. But do they provide a real solution for information handling? Architectural heritage is a part of History, and therefore it can be only partially described. What solution does one have when on one hand he does not really know how an edifice could be and on the other hand its "computer tool" calls for geometric exhaustiveness?

séducteur ? Quel genre de communication, sans parler de raisonnement, peut être instrumenté lorsque qu'un tel fossé existe entre la « vraie » connaissance, partielle, et une « fausse » détermination géométrique, complète « pour faire plus vrai »?

La représentation architecturale peut-elle intervenir comme un outil de visualisation scientifique utilisant la forme architecturale comme transmetteur de connaissance? Peut-elle aller au-delà du pléonasmе et nous aider à souligner les manques dans nos connaissances? Et si non, à quoi sert-elle vraiment pour des scientifiques? Telles sont les questions que pose la démarche de modélisation informationnelle.

Ces questions sont loin d'être nouvelles. On peut les reformuler par les mots d'E.R Tufte « ...Une décoration cosmétique, qui déforme souvent les données, ne sauvera jamais un manque sous-jacent de contenu ... » [15]. Autrement dit, il nous faut évaluer la capacité de la représentation architecturale à véhiculer des informations. »

Naturellement notre connaissance peut évoluer : la représentation devient un moment dans l'étude de l'édifice, une représentation chasse l'autre au fur et à mesure qu'avance l'étude. De plus l'édifice lui-même évolue dans le temps, nous voulons représenter pour chaque objet plusieurs objets, en fait chaque objet qu'un objet a été dans son histoire.

Il nous faut en définitive nous placer dans l'enseignement de J. Bertin : « ... comprendre c'est réduire la multitude des « données » qui nous assaillent au petit nombre « d'informations » que nous sommes susceptibles de prendre en compte autour d'un problème donné ... » [16].

La représentation architecturale dans le champ patrimonial nous apparaît dans ce sens comme un travail de tri sur les informations à manipuler, ne mettant pas en cause les techniques de représentation du bâti mais l'aptitude de la maquette à garder trace de notre connaissance évolutive sur le bâti: objet géométrique certes, mais aussi objet construit, objet documenté, objet en relations dans un ensemble composé, etc. (voir Fig. 3).

Dans la filiation des travaux de J. Bertin ou d'E.R. Tufte, notre démarche consiste à utiliser le graphique pour interroger des jeux de données, pour les trier, ou dit autrement pour les résumer. Dans cette logique, nous devons aujourd'hui faire émerger une démarche de **modélisation informationnelle** dans laquelle la représentation graphique des artefacts, quelle que soit l'échelle considérée, sert d'interface dynamique dans le jeu de données originelles et de visualisation de l'analyse de ces données.

Nous revenons sur cette démarche en présentant brièvement ses filiations, sa genèse et sa traduction sous la forme de « règles méthodologiques », forme conçue pour autoriser un large effort de validation de la démarche.

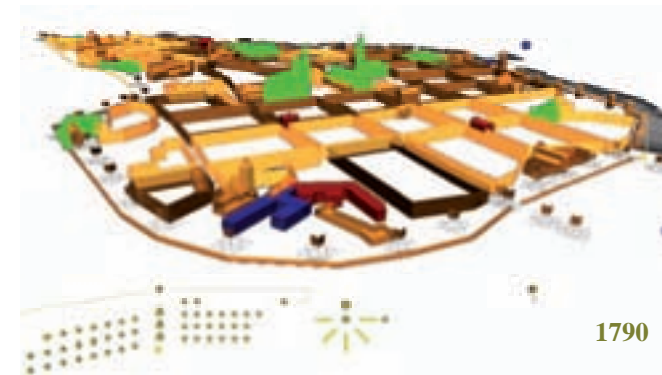
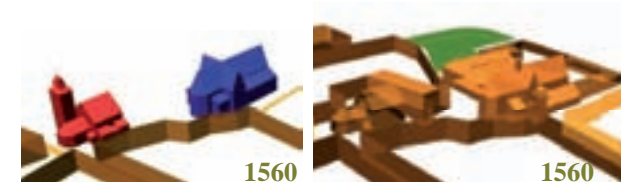


Fig. 3. Information encoding adapted to VRML: red or blue colouring marks the use of time analogies, emissive colouring stresses information lacks, etc. Green highlighting lets users to check what type of documents are available for each object. Interactive VRML selectors in the control panel allow queries on various DB for each object represented in a scene.



Evolution of the quantity and quality of data for individual objects automatically produces evolution of the graphics (scenes representing year 1560, one year interval between the querying of the system in left and right images). New information has been added (gardens, cloister, etc.) and information on the two churches is better defined (causing automatic change of colour) [Evolution of historical centre of Kraków, VRML, program ARKIW, 2004-2005, I.Dudek, J.Y. Blaise]

Our contribution introduces the genesis of an *informative modelling methodology* in which the representation of architectural objects is used as support for information search and visualisation. Architectural objects are described with regards to information sets that localise them in time and space. 3D or 2D models are calculated at query time and can consequently be used to deliver information on the objects they represent.

2 – Filiations

Partons donc de l'ambition de voir la représentation comme un *outil d'investigation*, outil de visualisation d'objets architecturaux **et** d'informations sur ces objet(s) et leurs histoire(s). Une telle démarche se situe tout à fait dans la continuité historique d'une part de la pratique du dessin d'architecture (*cf.* J.Cuisenier [17], D.Estevez [18]) et d'autre part dans celle de la représentation graphique comme « *système de signes que l'homme a construit pour retenir, comprendre et communiquer les observations qui lui sont nécessaires* » selon les mots de J.Bertin (*op.cit.*). Mais force est de constater que l'apparition des NTIC n'a pas contribué de façon notable à l'émergence de ce champ d'investigation à l'intérieur ou à la marge des STIC. C'est en creusant ces questions que s'est peu à peu imposée l'idée d'un champ d'investigation à formaliser qui fasse le pont entre le domaine de la modélisation spatiale proprement dite (représentation géométrique, multi-représentations, multi-résolutions, etc.) et celui de la visualisation d'information au sens d'E.R. Tufte [19] c'est à dire une démarche d'explication visuelle. Par le caractère spatial du sujet étudié, un objet architectural, cette démarche appelle une représentation (plus ou moins abstraite) du sujet lui-même dans l'espace « réel ». Mais par le caractère temporel et culturel du sujet étudié, cette démarche appelle une représentation non plus du sujet lui-même mais de notre analyse du sujet, autrement dit des informations dont nous disposons pour le comprendre.

La démarche de modélisation informationnelle, comme jeu de pratiques graphiques, s'inscrit donc dans une double filiation : celle de la représentation architecturale figurative, celle de la visualisation d'information (voir Fig.4). Mais au-delà de ce jeu de pratiques graphiques, la démarche de modélisation informationnelle est une démarche cognitive, dont l'objectif n'est pas la représentation de l'objet, fût-elle « juste », mais bien la compréhension de l'objet et de son évolution dans le temps (voir Fig.5). Nos travaux antérieurs ont parmi d'autres mis en évidence la nécessité d'élaborer une démarche de modélisation de l'objet et des connaissances qui lui sont associées, démarche que nous reconnaissons par les termes modélisation architecturale informationnelle, ou **modélisation informationnelle**. Cette pratique de la modélisation 2D/3D doit mettre en relation dynamique trois éléments :

- informations qualifiées par des descripteurs propres au domaine (incertitude par exemple),
- corpus d'objets architecturaux théoriques multi-échelles,
- maquettes virtuelles dans lesquelles les informations susmentionnées sont visualisées et délivrées par l'intermédiaire de codes graphiques affectés aux objets architecturaux.

Démarche méthodologique, la modélisation informationnelle vise dès lors à intégrer modélisation des artefacts et modélisation/représentation des connaissances évolutives qui leur sont associées.

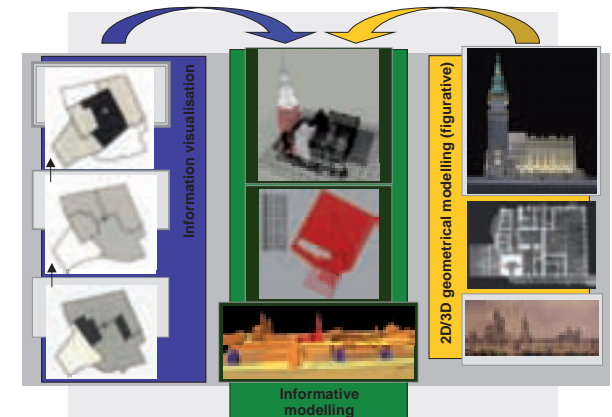


Fig. 4. Informative modelling: a graphic practice at the intersection of information visualisation and architectural representation:

left – visuals explanations (abstraction, data distribution, ...) [*Graphical analysis of a cholera epidemic in London 1859, in E.R Tufte, Visual..., op.cit.*]; right - the tradition of architectural figurative representation [*Ratusz Krakowski, programme AKIW, 2000, C.Radi; Ratusz Krakowski, plan, XX; Panorama Krakowa z ok. 1700, MHmK, aut. Wieniak.*]; middle – informative modelling [*Kraków, programme ARKIW, 2000-2005, Maya/SVG/VRML, C.Radi, J.Y. Blaise, I.Dudek*]



Fig. 5. As a practice of cognition, informative modelling stands at a crossroad of disciplines. [*aut. J.Y. Blaise, I.Dudek, 2006*]

En conséquence les filiations scientifiques de cette démarche vue comme pratique cognitive s'élargissent et croisent formalismes informatiques (représentation des connaissances, gestion de données spatio-temporelles, etc.) et problématiques liées à l'étude de l'architecture patrimoniale à différentes échelles (acquisition et gestion d'informations, caractère de l'hypothèse en sciences historiques, etc.).

C'est, nous semble t'il, en nous inscrivant dans la logique du « visualiser pour raisonner sur des informations » prônée par E.R Tufté que nous pourrions contribuer à sortir la représentation architecturale des miasmes de l'anecdotisme dans lesquels une dépendance trop étroite de l'analyste aux outils de modélisation 2D/3D l'ont enfermé. J. Cuisenier (*op.cit.*) a, avant nous, noté une continuité historique dans la façon dont la représentation architecturale vient traduire graphiquement des éléments de connaissance, depuis Vitruve bien en passant par Serlio et la renaissance, ou par les parallèles d'ordres antiques. Il nous semble d'une certaine façon que la thématique « modélisation informationnelle » que nous développons peut assurer cette continuité à l'heure des NTIC, avec l'aide ou malgré les manques de ces techniques numériques.

3 - Genèse

Dans le cadre de différents travaux sur les évolutions architecturales et urbaines de la ville de Cracovie (voir note 2.), nous avons été amenés à porter sur les outils et méthodes dont nous disposons un double diagnostic :

Un constat de manque - quelles solutions, quelles méthodes, quelles pratiques pour :

- faire de la forme architecturale un filtre spatial et temporel permettant d'intégrer des couches d'informations hétérogènes comme par exemple mesure et documentation;
- utiliser la maquette numérique figurant de telles formes, comme dispositif de visualisation d'informations itératif, construit et reconstruit au jour le jour qui doit devenir ce qu'est la carte pour le territoire (voir Fig.6).

Un constat de besoin : comment caractériser, pérenniser et mettre en partage notre compréhension du bâti au travers des fourches caudines de solutions informatiques impliquant souvent une forte dépendance économique-technique vis à vis de plate-formes commerciales ?

Nous sommes partis de l'hypothèse initiale que la morphologie est un intermédiaire efficace entre l'analyste et le jeu d'informations rassemblées sur l'objet architectural ou urbain à analyser. Ce constat peut s'expliquer en partant de ces trois formules :

- Du point de vue de la représentation : la maquette permet de formuler en termes de géométries ce que nous savons des édifices.



Fig. 6. Handling architectural evolutions, an opportunity to query the documentation by selecting a spatio-temporal artefact inside graphics, - schema.

[programme ARKIW, VRML/RDBMS, 2001-2005, I.Dudek, J.Y. Blaise]

Note 2. PICS 1150, programme ARKIW, UMR CNRS/MCC 694 MAP, en collaboration avec IHAIKZ WA PK et APN/ATIP n° n°35390,

<http://www.cnrs.fr/SHS/recherche/liste_articles.php>

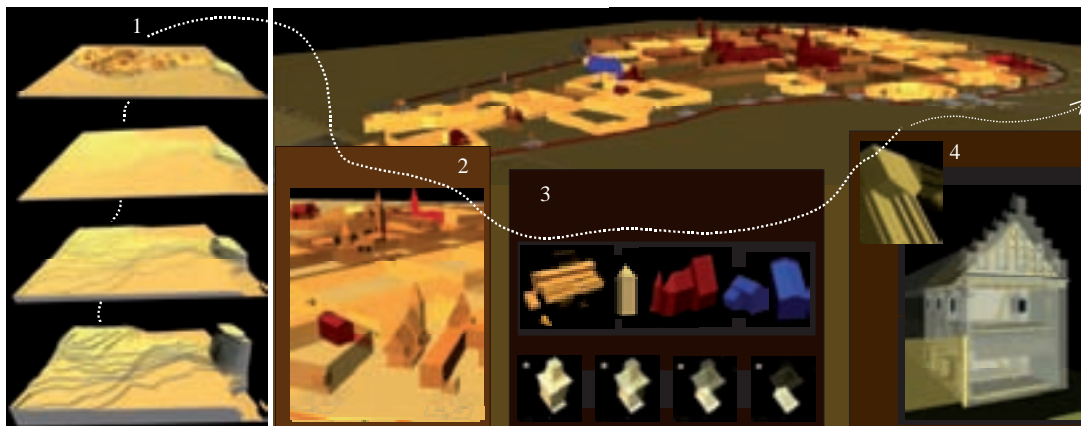
Studying an edifice or a site is a process in which one has to cope with various updatable elements:

1. Evolutions of edifices/sites through the time : we face the challenge to visualise shapes that in a way or another are always hypothetical
2. Evolutions of our knowledge about edifices/sites studied: the more we investigate them, the more information we will cross-examine, the better idea about their morphologies will be have.
3. A documentation that varies in type, precision and relevance.
4. A documentation that relates to elements at a given scale.

Architectural objects are therefore represented dynamically in order to figure an updated state of knowledge, they act as spatial and temporal filters on the data sets.

- Du point de vue de la documentation : les sources documentaires permettent de formuler en termes de références ce que nous savons des édifices.
- Du point de vue de la localisation : un lieu et un temps donné se caractérisent par la présence en ce lieu d'un édifice dont l'état est à considérer par rapport à ce temps donné.

A partir de là, nous avons choisi de construire un ensemble de représentations symboliques qui sont issues d'une analyse architecturale de l'objet et incluent, au-delà de la seule morphologie, les aspects documentaires. La représentation 2D ou 3D interactive d'objets architecturaux sert d'outil de navigation et d'investigation comparative dans un jeu d'informations hétérogènes et réparties. En retournant la proposition, nous pouvons affecter aux formes représentées dans l'espace des maquettes virtuelles des codes graphiques indiquant ce que nous savons sur l'objet (certain/incertain, typologieA/TypologieB, etc.) (voir Fig.7, 8).



Ces représentations ne nous montrent pas l'objet « vrai », souvent trop mal connu pour être représenté, mais l'idée que nous nous faisons de l'objet : elles traduisent au temps τ de l'étude notre état de connaissance. Ces maquettes sont construites dynamiquement en réponse à des requêtes sur les informations dont nous disposons :

- au temps τ de l'étude (ex : « état des connaissances le 17 mars 2005 »),
- sur le lieu λ (dénomination toponymique, voire une affiliation architecturale),
- au moment μ de l'histoire de ce lieu (ex : « ce lieu en 1455 »).

Elles peuvent donc positionner dans l'espace et dans le temps non seulement un objet ou des objets, mais les jeux de connaissances attachés à ces objets. En conséquence, elles agissent comme vecteur de tri et de comparaison dans un jeu d'informations. Partant d'une



Fig. 7. Time/Space 2D layering on Kraków's old town hall. [programme ARKIW, VRML/SVG, 2001-2005, I. Dudek, J.Y. Blaise]

Fig. 8. Examples of graphics that provide a dynamic link between three elements: pieces of information, a hierarchy of architectural concepts at various scales, a set of graphical codes used in order to visualise an evaluation of the nature or accuracy of the documentation attached to each architectural object represented in a scene. [programme ARKIW, VRML/SVG, 2001-2005, I. Dudek, J.Y. Blaise]

Our knowledge about objects evolves with time, the objects themselves evolve with time: representations simulate the morphological evolution of objects, as well as a transitional interpretation of the documentary sources used. In return such representations can be used as graphical interfaces containing query-able architectural objects [14]. Historical data as well as their interpretation can then be visualised and accessed through shapes representing architectural objects (2D/3D). That solution finds its root not in the field of geometric modelling but in the field of information visualisation, where the role of graphics as defined by E.R. Tufte [15] obviously better suits our goals: "... We envision information in order to reason about, communicate, document and preserve that knowledge ...".

problématique de représentation et de gestion de connaissances, cette méthode que nous proposons se situe donc bien en définitive à l'intersection des champs de la modélisation géométrique 2D/3D et de la visualisation d'informations. A cette approche s'applique un pré-requis: que la maquette numérique devienne une représentation interprétative et symbolique n'entretenant avec une réalité observée ou déduite qu'un rapport de confluence géométrique, et qui s'astreigne à une lisibilité qui est celle de la carte en géographie au sens large; support de connaissances à l'échelle du territoire (voir Fig. 9).

Pour ce faire nous avons dans un premier temps établi trois postulats simples :

- 1- Le corpus architectural, les formes physiques élémentaires constituant l'édifice sont un médiateur entre les informations à manipuler.
- 2- Puisque travaillant sur des objets disparus ou transformés, ces formes seront mal connues, leur représentation sera abstraite.
- 3- Dans la maquette 2D ou 3D, ces formes sont un outil de navigation (elles permettent à l'utilisateur d'interroger élément par élément les jeux de données et d'informations); mais aussi le vecteur de transmission d'une information, localisée dans l'espace et dans le temps.

L'application de ces trois postulats à de nouveaux terrains d'expérimentation et de nouveaux travaux débouche in fine sur une démarche de modélisation en gestation, la modélisation informationnelle, formalisée par un jeu de règles ou bonnes pratiques, présentées en section suivante.

4 – Quatorze règles (plus une)

Notre contribution affirme l'existence d'une démarche de modélisation qui s'appuie sur la double filiation établie plus haut. Précisons que cette démarche n'a pas vocation à déboucher sur une méthode unique de visualisation des connaissances relatives au patrimoine bâti mais plutôt d'intégrer au sein d'un dispositif de visualisation pivot différentes représentations des artefacts, chacune en relation avec sa couche d'informations. Dans la pratique, la démarche de modélisation informationnelle se matérialise par un jeu de règles de production graphique. Ces règles nous sont soufflées par ces mots E.R Tufte (*op.cit.*) « ... Nous visualisons des informations pour raisonner sur des connaissances, pour documenter, communiquer et préserver ces connaissances ... », mots, qui nous semble t'il, fixent à notre démarche un cadre clair.

La démarche de **modélisation informationnelle** que nous cherchons à circonscrire est incarnée dans un ensemble large de pratiques graphiques (voir note 3).

Il reste donc à rechercher notamment au travers de convergences entre pratiques d'hier et d'aujourd'hui la trace de *prescriptions sous-jacentes communes*, de règles qui matérialiseraient plus avant

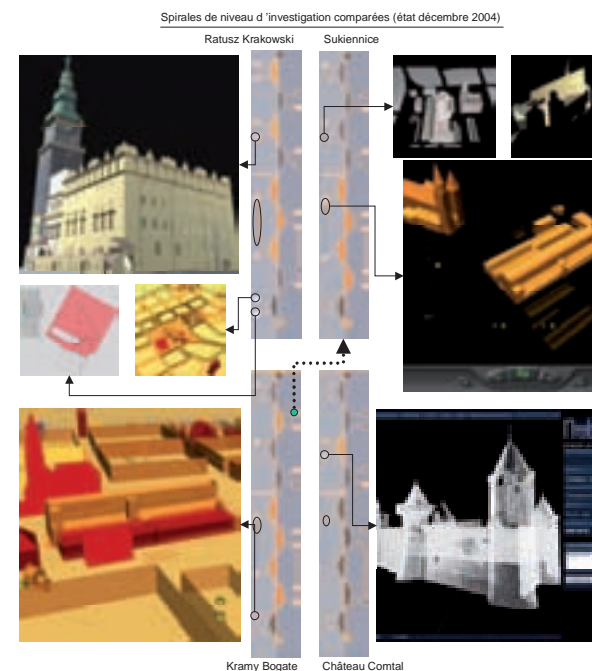


Fig. 9. Comparison of four MIR knowledge acquisition spirals corresponding to different architectural objects. Note visual difference of spirals - the best described object (Ratusz Krakowski) and the least known (Château Comtal), and heterogeneity of static representations. [top-left: restitution of Ratusz, Krakow, MAYA™ 2000, C.Radi; top right: simplified urban context, VRML, 1998-2005, I.Dudek, J.Y.Blaise; down right: cloud of points presented in the application developed by L. De Luca, real time Virtools™ 2004; Kraków, Various dynamic representations (bottom left, 3D, above it 2D) programme ARKIW, J.Y. Blaise, I. Dudek]

Note 3. Certaines sont expérimentées dans nos travaux (voir figures ou J.Y. Blaise [20]), voire en filigrane d'autres travaux contemporains (cf. F. De Domenico [21], P. Salonia [22], P.Alkhoven [23]). D'autres sont à construire sur la base de pratiques existantes dans les champs de l'architecture (cf. par exemple J. Tajchman [24]), de la visualisation d'informations (cf. par exemple R. Spence [25], K. Andrews [26]), ou plus largement de la gestion de données spatialisées (cf. S. Göbel [27]) ou spatio-temporelles (cf. A. Renolen [28]).

cette démarche. Nous en introduisons ici un premier jeu, distribuées selon quatre axes (informations, modèles, représentations, abstraction). Nous avançons la thèse que derrière ces « bonnes pratiques graphiques » pratiques d’hier et d’aujourd’hui il y a une démarche commune que nous nommons modélisation informationnelle. Dans ce cadre, il nous faut identifier des indicateurs permettant de la valider, et de définir des réalités concrètes derrière cette démarche. Ceci prend ici la forme de prescriptions, utiles pour celui qui, aujourd’hui, fait face à l’étude des évolutions d’un lieu bâti. Évaluer la portée, la généricité et l’applicabilité du jeu de devient une étape fondatrice de la démarche, et une façon de basculer de la simple observation de convergences à une volonté de formalisation et de déploiement de la démarche. Ces règles peuvent donc être vues comme une sorte de « check-list » dans la conduite d’une étude patrimonial. Mais elles peuvent également, c’est notre ambition, être une mise à l’épreuve de la démarche elle-même.

- Chaque donnée sur l’objet sera interprétée afin de pouvoir trier et distribuer l’information résultante en un ou plusieurs niveaux de lecture, appelés échelles informationnelles (voir note 1.).
- La représentation de l’objet renverra à l’ensemble de données et d’informations qui justifient sa présence dans le temps et le lieu que représente la maquette.
- La forme donnée à l’objet résultera d’une interprétation des données permettant de lui attribuer un degré de vraisemblance lisible dans la maquette.
- Pour chaque objet, la maquette devra signaler ce que nous savons ne pas savoir, et s’interdira une assertion non fondée sur des données.

- Un modèle théorique décrira de façon structurée les formes architecturales.
- L’objet figuré dans les maquettes sera instance de ce modèle.
- L’implémentation de ce modèle devra permettre la réutilisation, la comparaison et la pérennisation des informations sur les instances.
- Chaque concept du modèle relèvera d’une échelle informationnelle.

- La maquette sera la réponse visuelle, incarnée dans l’objet architectural, à une interrogation sur l’état relatif de nos connaissances.
- La maquette sera recalculée en temps réel pour réfléchir l’état relatif de nos connaissances.
- L’apparence donnée à l’objet exploitera un ensemble de codes graphiques à développer pour visualiser les informations le caractérisant.

- L’objet sera figuré avec des niveaux d’abstraction alternatifs en fonction des critères de l’échelle et/ou du degré de complétude de l’étude.
- L’étude de l’objet sera implémentée comme un processus non-ordonné intégrant des informations disjointes.
- Le degré de complétude dans l’étude de l’objet sera exprimé graphiquement en temps réel.

- Each piece of information about the object will be interpreted in order to distribute information among semantic layers called informative scales (see note 1.).
- The representation of an object will allow the user to retrieve data and information that justify the presence of the object at the time and date the representation shows.
- The shape given to the object will stem from an interpretation of the data stating the shape’s credibility and making it visible.
- For each object, the representation will show what we know that we ignore, and will not contain affirmations that would not be justified by relevant data
- A theoretical model will describe architectural shapes in a structured way.
- Objects represented inside 2D/3D models will be instances of the above-mentioned theoretical model.
- The implementation of the above mentioned theoretical model will allow the reuse, the comparison and the sustainability of the information on the instances.
- Each concept of the above mentioned theoretical model will be attached to a given informative scale.
- 2D/3D models will be the visual answer, displayed thanks to the representation of architectural objects, of a query on our state of knowledge.
- 2D/3D models will be calculated in real time so as to reflect our current state of knowledge at query time.
- The appearance give to an object will use a set of graphic codes that should be developed in order to visualise the object’s underlying information.
- The object will be displayed represented inside 2D/3D models with alternative levels of abstraction depending on both/either the scale observed and the level of knowledge reached in the investigation process.
- The investigation process will be implemented as a non-ordered process allowing the integration of disjoint sets of information.
- The level of knowledge reached in the investigation process on a given object will be represented in real time inside 2D/3D models.

Ces quatorze règles forment un réseau assez dense d'indicateurs sur la validité des représentations produites au cours de l'étude diachronique d'un lieu. Pourtant, il nous faut en ajouter une quinzième, plus large, et peut-être plus fondamentale :

> Si la maquette ne débouche pas sur un gain d'intelligibilité des informations qu'elle véhicule, alors elle est inutile.

Cette quinzième règle ou prescription matérialisant la démarche de modélisation informationnelle chapeaute par la pratique de l'auto-critique les quatorze premières. Cette règle ne fait en vérité guère plus qu'affirmer une ambition, qu'affirmer ce que nous supposons être un caractère discriminant du graphique tel que pratiqué en modélisation informationnelle. Dans cette pratique, nous cherchons à distribuer des informations au travers de formes architecturales. Pourquoi? Pour mieux discrétiser, analyser, représenter et mettre en partage ces informations ; mais aussi pour, en s'inspirant des travaux de J. Bertin, vérifier la propriété suivante: la représentation peut nous en apprendre plus que nous n'en savions à l'origine sur le jeu d'intrants (voir Fig. 11).

5 – Conclusion

La démarche de modélisation informationnelle pour l'architecture patrimoniale met en lumière des questions interdisciplinaires sur la représentation, comme outil d'investigation, outil de visualisation d'objets et d'informations. Elle fait pont entre le domaine de la modélisation spatiale proprement dite et celui de la visualisation d'informations. Elle s'appuie sur un croisement d'expériences et se veut fidèle aux particularités du champ d'application qu'est l'étude du bâti patrimonial (incertitudes, hétérogénéité des sources, etc.). Cette démarche repose à l'origine sur deux idées ou hypothèses simples :

- la forme, filtre spatial et temporel efficace,
- la représentation, dispositif de visualisation d'informations itératif.

Cette démarche se situe clairement à l'intersection de plusieurs disciplines, et interroge aussi bien le développeur de solution informatique que le praticien de l'analyse architecturale et urbaine. Démarche méthodologique, c'est aussi selon nous une pratique de l'interrogation interdisciplinaire (par exemple : l'outil de modélisation géométrique que j'utilise me permet t'il de rendre compte de la nature incertaine des informations que je manipule ? Quel lien entre le résultat graphique et sa justification documentaire ?). En ce sens, cette démarche peut le cas échéant remettre en cause technologies et méthodes dominantes qui, déguisées en solutions, font quelquefois plutôt partie du problème. Elle appelle en effet une distinction entre l'objectif (quel apport pour le chercheur, quelle pérennité des résultats, quel connaissance produite et partagée) et les moyens (quels outils, quels formalismes informatiques, quelles dépendances

The fourteen rules establish a grid of indicators permitting easier evaluation of the scientific value of representations. Still, it seems to us that a supplementary, more general rule, should be added :

> If a 2D/3D model does not produce a gain of insight on the information it displays, it should be considered worthless.

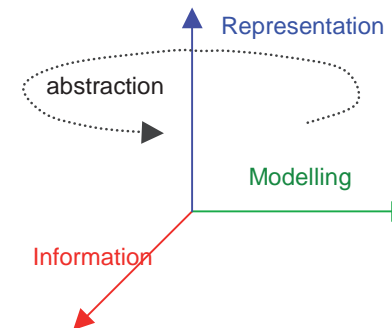


Fig. 10. A distribution along four axis of « rules » that would further define informative modelling as a methodological framework (see also[20],[29]).

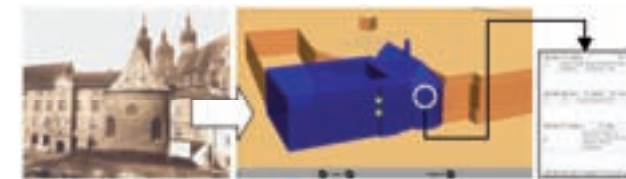


Fig. 11. An application of informative modelling as a method for knowledge discovering : iterative documentation querying. Left an I.Krieger's photograph stored as an iconographic item in a documentary DB. Middle the corresponding 3D scene calculated by selecting the photograph in the DB (the scene shows "all objects present in the photograph"). Right, a query on the objects inside the graphic display, a 3D scene, provides "all the other bibliographical items available" on one an objects interactively selected inside the 3D scene.

[Kraków, Kościół św. Barbary i Klasztor Jezuitów, ok. 1860, phot., I. Krieger; interactive scene, VRML, 2002-2003, I. Dudek, J.Y.Blaise]

induïtes). Formalisée par un jeu de règles agissant comme grille d'auto-évaluation, la démarche de modélisation informationnelle traduit donc peut-être une interrogation qui va au delà du seul champ d'application dont nous souhaitons parler.

Par une mise en discussion et en expérimentation, notamment dans le cadre de l'école thématique « MIA », nous espérons franchir un pas de plus dans l'identification de cette démarche, afin d'en établir une fondation théorique et pratique rigoureuse, d'en cerner les règles et limites, d'en juger l'apport en matière de production et d'échange de connaissances, et enfin d'en évaluer la portée aux différentes échelles par le filtre desquelles le territoire bâti est lu puis compris.

Références bibliographiques

- [1.] A. Palladio, trad. I. Ware, *“The four books of Architecture”*, Dover Publ., New York (1738) 1965
- [2.] J.L. Borgès, *“Fictions”*, Gallimard/Folio, Paris (1956) 1980
- [3.] Vitruve, trad. C.Perrault, *“Les dix livres d'architecture”*, Mardaga, Bruxelles (1684) 1988
- [4.] F.Fichet, *“La théorie architecturale à l'âge classique”*, Mardaga, Bruxelles 1979
- [5.] J.P. Saint-Aubin, *“Le relevé et la représentation de l'architecture”*, Service de l'inventaire général, Editions Documents & Méthodes, Paris 1992
- [6.] A. Perkins. *“The Cone Sisters' Apartments: Creating A Real-Time, Interactive Virtual Tour”*, [dans] Proceedings ICHIM 03, Paris 2003 <irc.umbc.edu/pdfs/ConeVRTour_1.pdf>
- [7.] A. Parush et D. Berman, *“Navigation and orientation in 3D user interfaces: the impact of navigation aid and landmarks”*, Elsevier Ltd., 2004, pp. 375-395
- [8.] L.Kobbelt et M. Botsch, *“A survey of point-based techniques in computer graphics”*, Elsevier Computer & graphics, 2004, pp. 801-814
- [9.] R.Oxman, *“Visual Emergence in Creative Collaboration”*, [dans] Proceedings of ECAADE Conference, Liverpool 1999, pp. 357-363
- [10.] S.F. Qin et al., *“From on-line sketching to 2D and 3D geometry: a system based on fuzzy knowledge, Computer-Aided Design, Vol.32, no 14, December 2000, pp. 851-866*
- [11.] F. Ramondino, *“From point cloud to surface : the modeling and visualisation problem”*, [dans] Proceedings of ISPRS 2003, Vol. XXXIV -5/W10, Tarasp-Vulpera 2003, <http://www.photogrammetry.ethz.ch/general/persons/fabio/tarasp_modeling.pdf>
- [12.] I. Suveg et G.Vosselman, *“Reconstruction of 3D models from aerial images and maps”*, [dans] ISPRS Journal of Remote Sensing, January 2004, 58, 3-4, pp. 202-224
- [13.] L. De Luca et al., *“Semantic Based Modelling and representation of patrimony buildings”*, [dans] Proceedings of SVE'05 conference: Semantic Visual Environments, Villars 2005,

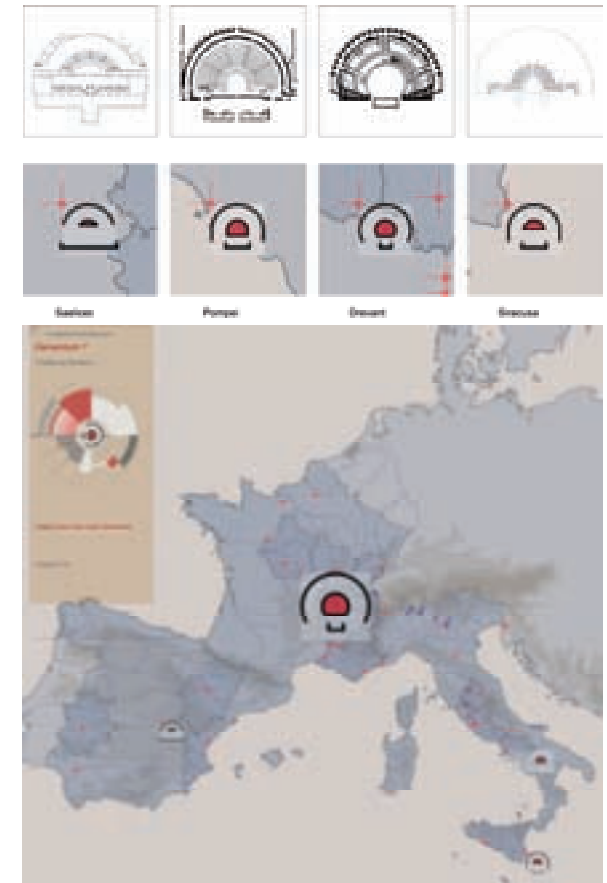
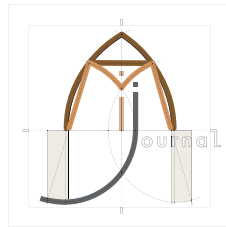


Fig. 11. An application of informative modelling as a method for information spatialisation and comparison. Top, morphology of the theatres is analysed in order to derive parameters of the physical object which are then converted into typological indications, and finally into visual signs. Those visual signs are used to distribute objects inside a pseudo-cartographic interface in order to facilitate comparisons. Bottom image, top left corner: “visual signature” of a theatre (case of Drevant-Derwentum ?), each sector of the visual signature corresponds to a given information (dates, size, state of despair, etc.) Sectors marked in white identify visually lacking information. [prog. STRABON, 2006, J.Y.Blaise, I.Dudek, F. De Domenico]

- [14.] I. Dudek et J.Y Blaise, “*Exploiting the architectural heritage’s documentation*”, [dans] Proceedings of I-Know 03 Conference, JUCS, Graz 2003, pp. 128-134
- [15.] E.R. Tufte, “*Emisioning Information*”, Graphic Press, Chershire 2001
- [16.] J. Bertin, “*Sémiologie Graphique*”, Editions de l’EHESS, Paris (1967) 1998
- [17.] J. Cuisenier, “*La maison rustique; logique sociale et composition architecturale*”, PUF, Paris 1991
- [18.] D. Estevez, “*Dessin d’architecture et infographie* ”, CNRS Editions, Paris 2001
- [19.] E.R. Tufte, “*Visual explanations*”, Graphic Press, Chershire 2002
- [20.] J.Y. Blaise et I. Dudek, “*Modélisation informationnelle : un cadre méthodologique pour représenter des connaissances évolutives spatialisables* ”, [dans] Actes du colloque EGC, Lille 2006, pp.347-358
- [21.] F. De Domenico et al., “*Architectural Modelling and Information Interfacing : Learning from Three Case Studies* ”, [dans] Proceedings of ITI 2004 Conference, Cavtat 2004, pp. 341-346
- [22.] P. Salonia et al, “*Virtual reality metaphor for data handling and retrieval*”, [dans] Proceedings of EVA ‘04, Florence 2004, pp. 210-215
- [23.] P. Alkhoven, “*The changing image of the city- A study of the transformation of the townscape using Computer assisted Design and visualisation techniques* ”, University of Utrecht, Utrecht 1993
- [24.] J. Tajchman, “*Stropy drewniane w Polsce. Propozycja systematyki*”, Ośrodek Dokumentacji Zabytków, Warszawa 1989
- [25.] R. Spence, “*Information visualisation*”, Addison Wesley ACM Press, Harlow 2001
- [26.] K. Andrews et al., “*Infosky: visual exploration of large hierarchical document repositories*”, [dans] Proceedings of HCI 2003 Conference, Crete 2003, vol. 3, pp. 1268-1272
- [27.] S. Göbel “*GeoLibrary Metaphor-based Information and Navigation Space to Access GeoDataArchives*”, [dans] JUCS, [dans] Proceedings of I-Know 03, Graz 2003, pp. 121-127
- [28.] A. Renolen, “*Conceptual modelling and spatiotemporal information systems : how to model the real world*”, [dans] Proceedings of ScanGIS 97, Stockholm 1997, pp. 35-53
- [29.] I. Dudek et J.Y Blaise “*From artefact representation to information visualisation: genesis of informative modelling*”, [dans] Proceedings of SmartGraphics 2005, Frauenwörth Cloister 2005, pp. 230-236
- [30.] C. Sitte, trad.G.R.Collins et C.C. Collins, “*City Planning According to Artistic Principles*”, Phaidon Press, London (1889) 1965
- [31.] R. Wittkower, “*Architectural principles in the age of humanism*”, Academy Editions, London 1973
- [32.] J. Le Goff, “*La civilisation de l’occident médiéval*”, Arthaud, Paris 1965
- [33.] A. Choisy, “*Histoire de l’Architecture*”, Inter-livres, Poitiers(1899) 1991
- [34.] E. Viollet Le Duc, “*Entretiens sur l’Architecture*”, Mardaga, Bruxelles (1863) 1977

Liste des auteurs / Author index

<i>Patricia ALKHOVEN</i>	117
<i>Jean-Yves BLAISE</i>	143
<i>Francesca DE DOMENICO</i>	105
<i>Livio DE LUCA</i>	131
<i>Iwona DUDEK</i>	143
<i>Wolfgang KIENREICH</i>	7
<i>Marta MAREK</i>	93
<i>Antonella NEGRI</i>	65
<i>Christine PARENT</i>	51
<i>Paolo SALONIA</i>	65
<i>Renato SALERI</i>	19
<i>Alberto SDEGNO</i>	39
<i>Stefano SPACCAPIETRA</i>	51
<i>Jan TAJCHMAN</i>	27
<i>Antonina ŽABA</i>	81
<i>Esteban ZIMANYI</i>	51



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