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3D as a content, 3D as a metaphor.

Experiments on distributing and interfacing information about historic artefacts using spatio-temporal visual disposals.

Jean-Yves Blaise
Iwona Dudek

UMR CNRS/MCC 694 MAP, France
jyb@gamsau.map.archi.fr
idu@gamsau.map.archi.fr

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Architectural heritage, 3D, Interfaces, Information visualisation, Spatio-temporal data.

Categories

H.3.3 [Information Search and Retrieval] Information filtering

H.5.2 [Information interfaces and presentation] user Interfaces

The importance we attach to 3D is probably related to the manner we perceive the world. Humans in general seem attracted by representations that are close to their perception. They represent objects and preserve information that seems important to them (ex. architecture). Archiving 3D data has at all times been a matter of will more than a matter of means. Since the XIXth century considerable efforts have been made to keep trace of 3D artefacts with the development of photogrammetry.

The creation, the use and the archiving of 3D content is today at a technological and methodological crossroad, with a number of sustainability challenges clearly still open. With more technologies available and a renewed eagerness of data holders to develop spatial interfaces (including within GIS systems), the perennial handling of 3D content and associated information has become a challenge in itself. Indeed, 3D models have for now two decades flourished in and around the field of architecture and especially when seen as heritage. But their making, often “in spontaneous generation”, and the variety of their uses leaves researchers and practitioners with a number of unanswered questions on:

- how to handle the growing heterogeneity of 3D data acquisition procedures,*
- how to distribute and access information inside 3D models / metaphors.*

In this contribution we wish to focus on the artefact itself (i.e. a 3D phenomenon) and on how to gain insight on its creation and its transformation. Our claim is that understanding of architectural artefact requires an analysis of evidence that does comprise 3D data, but that obviously requires much more than that. Accordingly we very briefly consider the “3D as a content” issue in the first section, and then detail various experiments where 3D act as a mean to distribute in time and space what in our mind should be the centre of our concern : the information about the artefact.

1 - Introduction

The importance we attach to 3D is probably related to the manner we perceive the world. In general humans seem attracted by all types of representations that are close to their perception - perspective views¹, 3D models (physical or digital), etc. Since centuries people represent and describe architectural objects, preserving information about them. Since the XIXth century, with the development of photogrammetry (métrophotographie - Laussedat, photogrammetry - Meydenbauer)², considerable efforts have been made to collect three-dimensional data. However, while techniques and technological solutions were upgraded, modified and improved, systematic surveys of architectural object were in a number of cases abandoned. In other words, it appears today that collecting and archiving 3D data is rather a matter of will than a matter of technical means.

Note 1. Brunelleschi's perspective views opened the way, with shortly after Alberti's more theoretical approach (1443).

Note 2. see Jean-Paul Saint Aubin J.P. Saint Aubin, "Le relevé et la représentation de l'architecture", Service de l'Inventaire Général, éd. Documents & Méthodes, 1992



In this contribution we wish to focus on the artefact itself (*i.e.* a 3D phenomenon) and on how to gain insight on its creation and its transformation. Our claim is that understanding of architectural artefact requires an analysis of evidence that does comprise 3D data, but that obviously requires much more than that. Accordingly we very briefly consider the “3D as a content” issue in the first section, and then detail various experiments where 3D act as a mean to distribute in time and space what in our mind should be the centre of our concern : the information about the artefact. Most of these experiments have been carried out in the historic centre of Cracow, former capital of Poland (see Fig.1), a city where the amount and heterogeneity of archival material exemplarily underlines the necessity to rethink the use of 3D in historic analysis.

Fig. 1. Cracow in the beginning of XVII century
[Vischer Merian, copperplate, Muzeum XX Czartoryskich, Kraków]

2 - 3D as a content

Architectural representation and surveying techniques have known in the last few years important evolutions with the development of new tools and methods for 3D data acquisition. However it is important to note, that we need more than three parameters (co-ordinates x,y,z) to describe univocally an artefact (eg. material, style, time related indications, etc.) if we wish to view the artefact as more than a purely geometrical object³. Although techniques and methods applied to acquire and describe 3D architectural content have deeply evolved, practices and methods remain poorly adapted to architecture. In field of the architectural heritage, may researches focus on the automation of the survey process or on the exploitation of results, they most often treat architectural surveying without any reference to its specific universe of knowledge. Our position is that key questions remain to be fully addressed, for example:

- How can the heterogeneity of 3D data, acquired with emerging technologies, be dealt with?
- Should any interpretation be done before “memorising” the data?
- Should all of this data deserve to be perennially preserved, and if so what standards now and to come?
- What are the expectations and the real needs on the user side (in terms of description of the 3D content - ontology – vocabulary, etc.) ?
- Can general purpose information search and retrieval metaphors be derived from renewed 3D data acquisition procedures?

In this first section of the paper, we shall only introduce what we view as methodological division lines: “3D” understood as “content” means for us 3D data, and accordingly data acquisition, storage and analysis issues will very briefly be quoted. However our experience with handling 3D content shows that bringing a concern for semantics⁴ to the fore *once 3D data has been acquired or modelled* is not the most efficient approach (euphemism). On the contrary, we believe that 3D is only a sub-set of an artefact’s features. The artefact’s analysis bases primarily on an in-depth analysis of documentary sources. Bringing together sources poses significant management and interface problems, on account of the quantity of documents as well as of their considerable heterogeneity and often extensive distribution. As a consequence, our contribution will not be centred on 3D as a content - a hot technological topic, but a cold scientific topic.

2.1 - Acquisition

Photogrammetry and photo-modelling techniques are survey methods where the post-processing of the data somehow inherits from traditional topography: sets of points are chosen by users. The acquisition phase here is therefore only acquiring adequate photographic material.

Note 3. see J.Y. Blaise, I. Dudek, L.De Luca, F. De Domenico “*Architectural Modelling and Information Interfacing : Learnings from Three Case Studies*”, proceedings: ITI 2004, Cavtat 2004,

Note 4. A concern for semantics visible in many initiatives like the COST Action TU0801 “Semantic enrichment of 3D city models for sustainable urban development” <www.cost.esf.org/domains_actions/tud/Actions/3D_City_Models>

On the other hand, laser scanning acquires global clouds of 3D points, and have been widely used in the field of the architecture⁵, at scales ranging from urban studies to sculptures. Marbs⁶ gives a good overview of such researches. But if results of numerous experiences show the growing quality of tools in terms of precision and speed, they also stress how difficult it still is to exploit the clouds of points resulting from the survey⁷. In both cases the very nature of the phenomenon observed – historic artefacts – is ignored at acquisition time. In short, in the field of the architectural heritage, 3D data acquisition poses today problems of method that seem still unsolved: surveying edifices most probably requires a specific approach, a pre-processing approach that fails to emerge.

2.2 - Storage

Digital storage of 3D data poses at least two major problems: the perennial maintenance of the support on one hand, and the perennial accessibility of the data on the other hand (format, software, hardware). Both issues are technology-related issues that we wish not to investigate here. A number of initiatives for the establishment of XML-derived formalisms (GML for instance, and its extension to urbanism cityML) show that a concern about semantics is growing. It is too early to say whether these initiatives will allow to handle the specificity of heritage architecture (partial, uncertain, contradictory data for instance).

2.3 - Analysis

Why acquire and store 3D data, if not to use it? And what may “using 3D data” mean in the field of the architectural heritage? Well according to us it means handling the spatial features of an artefact, and not trying to find some kind of artefact inside 3D data sets. So obviously the problem is to analyse the mass of 3D data in order to identify some kind of information on the edifice by linking the data with pieces of knowledge.

Our experiences show that identifying and organising non-ambiguous theoretical elements of morphology is a key step in attaching various pieces of information, including raw results of surveying campaigns. This however can only be achieved if elements of knowledge are given the central role in the survey-modelling-representation chain. 3D representations help understanding architectural changes because a typological analysis of the field of experimentation provides divisions lines inside 3D data sets. A methodological milestone, P. Alkhoven’s analysis of Heusden’s urban development clearly shows where 3D data analysis can fruitfully complement historical analyses.

Note 5. see Van Den Heuden FA, 3D Reconstruction from a single image using geometric constraints ISPRS Journal n° 53, 1998, Elsevier

Note 6 see Marbs, A., Experiences with laser scanning at i3mainz – CIPA Int. Workshop on Scanning for Cultural Heritage Recording - Corfu,Greece-2002

Note 7. see F. Ramondino, From point cloud to surface : the modeling and visualisation problem – International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, vol XXXIV- 5/W10- 2001

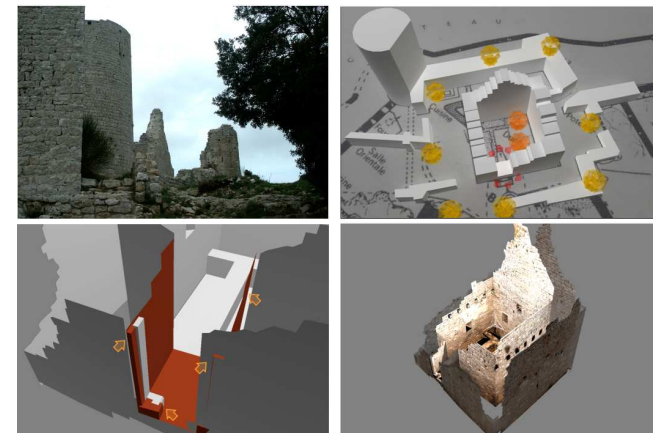


Fig. 2. Surveying historic artefacts: acquiring 3D data on the remains of the deserted medieval site of Rougiers

3 - 3D as a metaphor

The title of this section's is a clear reference to the eponym notion in information visualisation⁸. Our aim is to introduce various experiments where 3D models of artefacts act as “spatial metaphors” enabling the distribution of pieces of information in time and space⁹. But, as will be shown, “3D” should not be restricted to the three dimensions of an artefact's virtual model (see Fig.3). Some of the presented experiments privilege 2D spaces over 3D spaces, in order to better achieve our goals, perfectly summed up by this quotation from E.R Tufte¹⁰ :

- Placing the data in an appropriate context for assessing cause and effect,
- Making quantitative comparisons,
- Considering alternative explanations and contrary cases,
- Assessment of possible errors in the data reported in graphics.

When trying to understand an historic artefact and its developments through time, 3D should not be seen as a starting point but as yet another mean to portray the artefact. Accordingly, we shall not put the focus on where and how 3D data were acquired, stored and analysed but rather on what was done with it. The experiments are therefore presented briefly, with indications of related bibliography. Behind the various experiments presented there is a global approach, a common methodological framework called informative modelling¹¹, situated at the intersection of the fields of 2D/3D architectural modelling and of information visualisation. The idea is to link meaningful elements of architecture (i.e. corresponding to canonical shapes) with pieces of information. Each of these elements acts as a vector for sorting, visualising and comparing their respective pieces of information. We base on three simple assumptions:

- Architectural corpus, the basic physical forms of the building, mediate between the information to be handled ;
- As we will be working with objects which have either disappeared or changed, these forms will be little known and will be represented with a relevant level of abstraction;
- In 2D or 3D models, the corpus is a browsing tool (allowing users to investigate sets of data or information element by element).

These representations do not show us the “real” object, often poorly known, but how we understand it. They are created dynamically in response to queries about available information:

- at time τ of the study ;
- in position λ (toponomy, architectural affiliation) ;
- at moment μ of the history (e.g. this place in 1455).

Note 8. W.Kienreich, Information and Knowledge Visualisation: an oblique view», MIA Journal Vol0 Numb.1, (2006)

Note 9. J.Y. Blaise, I. Dudek, *Visual tools decipher historic artefacts documentation*, Journal Of Universal Computer Science, (2007) 456-463, Know-Center J.UCS I-Know 2007, 7th International Conference on Knowledge Management, KVD Workshop (2007-09) (2007) Autriche ISSN 0948-695x

Note 10. E.R Tufte, *Visual Explanations*, Graphics Press, Cheshire 1997, pp. 29-35

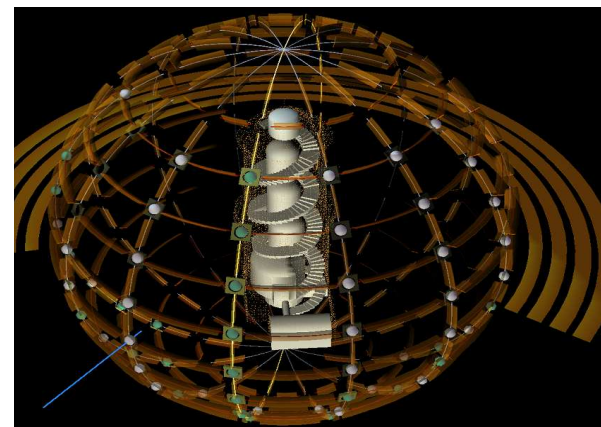


Fig. 3. Euclidian space, projective geometry: the Infosphere combined metaphors [J.Y. Blaise I. Dudek, “Infosphere: one artefact two metaphors, three search criteria” – section 3.4.1.]

Note 6. see J.Y. Blaise, I. Dudek, *From artefact representation to information visualisation: genesis of informative modelling*, Proceedings of 8th Smart Graphics International Conference, (2005) 230-236 Springer, LNCS 8th Smart Graphics International Conference (2005-08) (2005) ISBN 978-3-540-28179-5;

J.Y. Blaise, I. Dudek, *Informative modelling*, MIA Journal Numb.1S, (2007)

Accordingly, implementing such representations involves an overlapping of themes:

- taking into account uncertain and heterogeneous information;
- considering the evolution of our knowledge;
- producing (dynamically) 2D/3D graphics;
- adapting our practices to the specific realities of the heritage field (uncertainty should forbid graphic assertions, what is unknown should be highlighted rather than hidden, etc.).

Case studies we report hereafter should be understood as test fields for this global approach, thanks to which we have repeatedly tried to bridge the gap between “3D centred approaches” and “information-centred approaches”.

3.1 - Distributing information in space

The morphology of architectural objects can be used in the spatial and temporal distribution of pieces of information. Objects thereby act as filters enabling a selection within the mass of information. Consequently the 2D/3D model (projective geometry) can be exploited for scale-driven navigation like a geographical map is.

3.1.1 SOL - bibliographic, iconographic and cartographic catalogue

The city of Kraków developed significantly during the first six centuries of the second millennium, before entering a period of relative decline when the Swedish monarchs moved the capital of the kingdom to Warsaw. This relative decline constitutes an opportunity for us today, as the city experienced little significant change during the nineteenth and twentieth centuries compared to other cities of similar size.

Moreover, years of preservation and investigative actions have resulted in the production of a large quantity of documents (descriptions, analyses, drawings, photographs, plans, etc.) which need to be collected, organised and visualised.

The objective was thus to use information technologies for better management and preservation of the documentation, and ultimately for a better understanding of the urban ensemble and its elements.

SOL (Sources On Line) has been initiated (1999) as a bibliographical, iconographical and cartographical database search tool for the web. SOL's thematic scope is the successive urban development of Main Square in Kraków (Poland). Each document is described in a conventional way (author, editor, etc.). Besides that SOL uses a thematic bias approach that takes into consideration elements of information that do not fit in a traditional bibliographical

Some publications related to the experiment:

J.Y. Blaise I. Dudek, “SOL : *Spatial and historical web-based interface for On Line architectural documentation of Kraków's Rynek* proceedings: 17th Conference of eCAADe, Liverpool 1999, ISBN 0-9523687-5-7, pp. 700-707

J.Y. Blaise, I. Dudek, “*Interpretative modelling as a tool in the investigation of the architectural heritage: information and visualisation issues*”, proceedings: VIIP 2001 (Visualisation, Image and Image Processing), Marbella 2001, ACTA Press, ISBN 0-88986-309-7, pp. 48-54

J.Y. Blaise, I. Dudek, “*3D Models as Visual Interfaces for Documenting the Architectural Heritage: The Defensive System of Kraków*”, ACTA Press, proceedings: VIIP 2002, Benalmadena 2002, ISBN 0-88986-354-3, pp. 746-751

J.Y. Blaise, I. Dudek, “*Exploiting the architectural heritage's documentation: a case study on data analysis and visualisation*”, Journal Of Universal Computer Science, I-Know 03, Graz 2003, ISSN 0948-695x, pp. 128-134

cataloguing. It gives a possibility of a multi-aspect search (architectural objects, historical period, orientation, media type, location in public libraries and archives, etc.).

Each SOL document:

- has a link to one or several architectural or urban objects (described in the document),
- has a link to one or several libraries in which it is available,
- is indexed using description specifying historical period(s) and thematic bias,
- is linked to a distinct point of view which indicates the position and the direction of view (for illustrations only),
- has an URL address allowing to link a complementary Web document.

A document referred in the database can be searched either through a graphic interface (2D, 3D-VRML) (see Fig. 5) or through a text-based interface.

Observations and conclusions:

- The multi-aspect content-based search is possible only if it was preceded by a step of content analysis of the source data.
- A content-based search relevancy relies on the researcher's analysis of sources.
- Various types of search interfaces (text-based, plane-based, 3D model) give different possibilities of queries. They may be used as complementary interfacing methods and should not be considered as equivalent.
- In the SOL management system we used a mono-scale 3D-representation mode that allows interfacing the database of documentation. Although in this project the use of a mono-scale representation mode can be justified by relatively modest area of investigations, limited to the zone of Market Square (200m X 200m), we have faced some problems related to a lack of a correlation between the documents to interface and the architectural forms that have been represented. The experience of SOL has clearly demonstrated that in the case of the urban architecture the mono-scale representation mode does not correspond to a diversity of available data and information and proved the indispensability of multi-scale representation. Our conclusion is that the documentation management systems dedicated to the architectural and urban heritage should filter the data through the concept of scale.

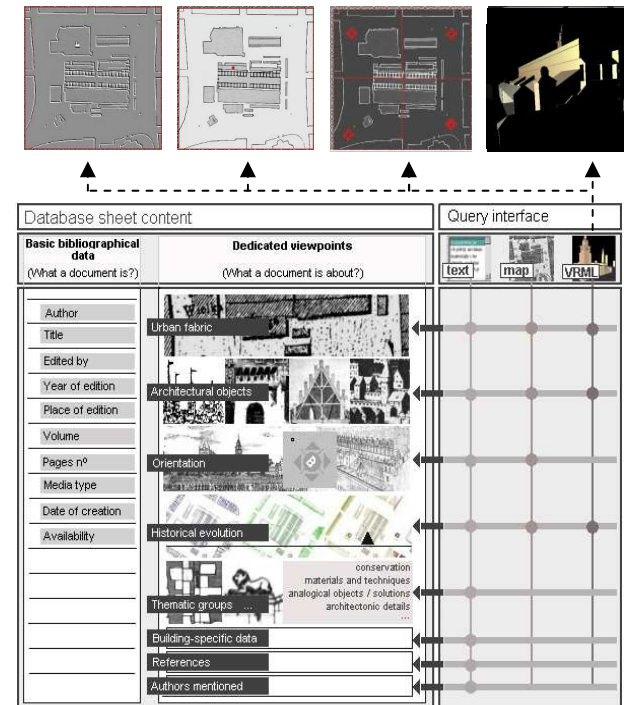


Fig. 5. SOL - database content and query modes
[ARKIW, 1999]

3.1.2 2D visual comparisons on a group of ancient theatres.

Traditional 3D virtual models do help unveiling the way elements of architecture “look like”, and sometimes the way are combined in space. But their readability is far from being optimal when trying to assess and compare specific architectural features inside sets of case studies. Cartographers have, at the scale of geography, shown us the way: maps introduce a *reduction of reality* and a visual codification of the features to analyse based on a limited set of *graphic variables*. So when the information concerning architectural elements is not geometrically exhaustive, or when the geographical coverage of elements spatially distributed is vast, or when the main objective is quantitative or qualitative comparison, the use of 3D graphics should not be a “default behaviour”. It should be the result of a statement of need – if to that statement 2D graphics answer better, 2D graphics should be preferred, even though they are less trendy. The experiment presented here shows a combination of more or less abstract 2D graphics can be an efficient tool in the visual comparisons of architectural artefacts.

The main focus of this development is to try out and implement 2D visual comparison mechanisms in order to analyse sets of information concerning antique theatres. We thereby expected to better understand and communicate the typology of the theatre. We also expected this development to give us through visual means a synthetic view of how the theatre typology evolved in time and space, around the Mediterranean basin. These comparisons should ultimately allow us to evaluate in a synthetic form what we know (composition and data on each theatre, synthesised in a visual signature; comparison of all theatres parameter by parameter) and also what we do not know (highlighting missing information). The comparisons underline the following questions:

- What do we know about object A compared to what we know about B, C and D?
- From what we know about B, C and D, what can we deduce about object A (at the hypothetical level of course)?
- What can we learn about the evolution in time and space of the typological family [A,B,C,D] by observing for example that, compared to the general model of the classical theatre, A and D have an extra characteristic Φ and that C and B have an extra characteristic Σ ?

A set of 36 antique theatres in four Mediterranean countries was chosen for this experiment. The “antique theatre” typological family can be understood as what J.Bertin calls the invariant of a graphic, and locations and features of each antique theatre inside the data set play the role of “elements of variation”.

Publication related to the experiment:

J.Y. Blaise I. Dudek, F. De Domenico, *Spatial distribution and visual analysis of architectural semantic features*, Journal Of Universal Computer Science, (2006) (2006) 498-506 Know-Center J.UCS I-Know 2006, 6th International Conference on Knowledge Management (2006-09) (2006) Autriche ISSN 0948-695x

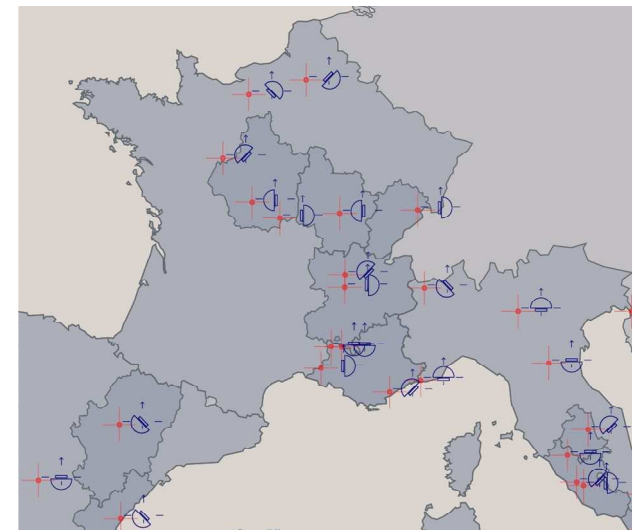
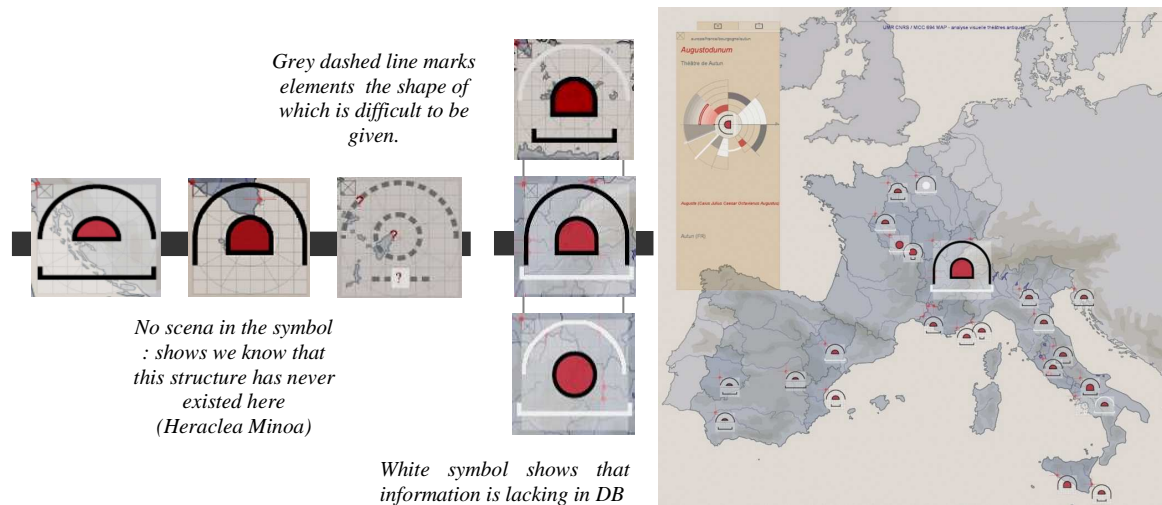


Fig. 6. Distributing in space, and comparing visually the values of specific features on the case of antique theatres: here a simplified representation of the theatres’ orientation underlines in a clear-cut manner the absence of a systematic rule in orienting theatres during the Roman era (somehow surprising for a period usually known for standardisation in public architecture. [STRABON, 2006]

The proposed method can be described in three key steps:

- A formal analysis of the typology to define the parameters and characteristics to be compared as well as the graphic sign used for the comparison. The result of this first phase is a univocal graphic sign symbolising the specific architectural composition of each theatre, as well as a database of relevant information (see Fig. 7).
- A set of visual signs calculated dynamically for each theatre and displayed in an interactive “architectural” map showing the spatial distribution of the theatres.
- A set of interactive tools within this “architectural” map, allowing the users to query the data base (see Fig. 7).



The results of this experiment illustrate what we mean by *informative modelling*: an approach, a practice, by means of which we can move from artefact representation to information visualisation. Moreover, this experiment provides convincing answers to a certain number of critical questions raised in the architectural heritage field:

- adaptation to a discontinuous knowledge acquisition process,
- adaptation to highly heterogeneous data, information and applications,
- enhancement of visual comparisons – both on quantitative and qualitative information.

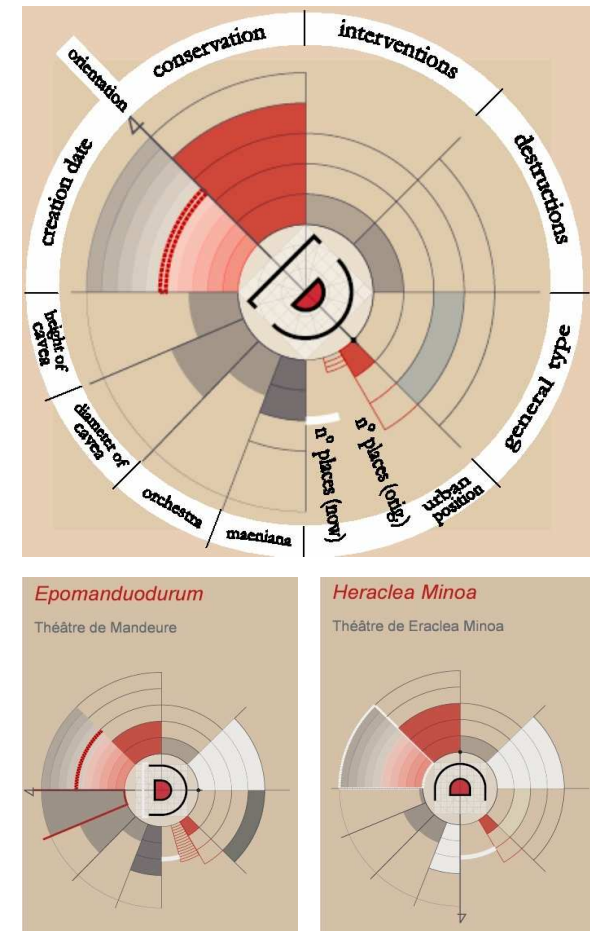


Fig. 7. Summing up the antique theatre’s features in an abstract, 2D, comparison-enhancing visual sign. [STRABON, 2006]

3.2 - Distributing information in time & space

The notion of time is indispensable to study and describe processes. Studying evolution of an artefact (or ensemble of artefacts) requires introduction of a temporal continuum. In this section we present experiments through which 2D or 3D disposals are used to distribute pieces of information in space (this of the disposal) and in time (the time slot to which the disposal corresponds).

3.2.1 VIA / SOL2 - Knowledge management and visualisation platform for the architectural heritage

The methodology used by historians of architecture in analyses of architectural evolutions of an object is based on interpretation and comparison of various types of documentation. Therefore the idea that different pieces of documentation are in relation to architectural elements, is a natural (although often unspoken) element of their work methodology.

In VIA/SOL2 experiment 3D models of edifices are considered as interpretation of information that we link to elements of architecture. 3D models can be used later on in a process of information retrieval (*i.e.* searches for the pieces of documentation describing the architectural evolutions of represented objects).

Data used in analyses of an architectural evolution of an object are often considered as approximate and uncertain, that is why we turned to an interpretative visualisation that uses a language of symbols. In this case a representation reveals only what is important in a context of a particular question, showing what the object is (ex. a basilic), but not how it is (ex. the details of construction). This type of representation exploits the semantic graphic codes in order to:

- underline inconsistency in the documentation or its analysis,
- indicate the level of incompleteness concerning the investigation,
- provide an updated visualisation of our knowledge on an object.

This development introduced several stepforwards:

- The definition of alternative scales for architectural concepts in order to better support the documentation's variety (see Fig. 9).
- The implementation of visual interfaces that not only allow to use a 3D model to formulate a query but also to calculate an answer that query in a form of 3D model (calculated online and featuring only the concepts corresponding to the query results) (see Fig. 8, 10, 11).
- The implementation of “justifiers” that are used in order to visualise an evaluation of the documentation accuracy.

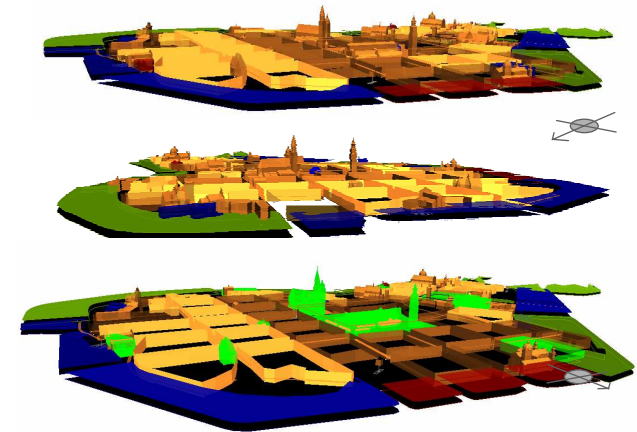


Fig. 8. Several 3D disposals, several time slots: colours connect each element of architecture with specific indications on their “documentary status”

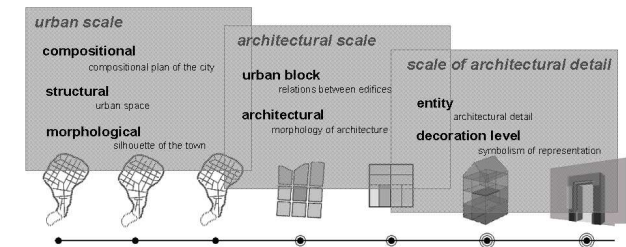


Fig. 9. The system of seven scales corresponding to the diversity of documentation content

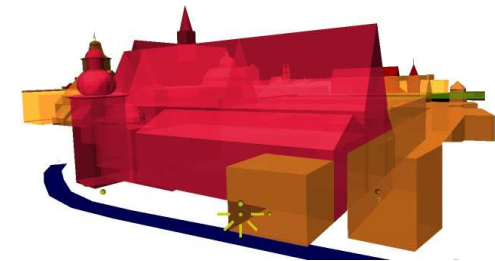


Fig. 10. Alternative levels of transparency are used in order to make visible, in a simplified way, the likelihood evaluation.

- The support for variations through time of each architectural object with preserving its identity (variations of: a shape, a location in a space, etc.)

VIA/SOL2 experiment focuses on the evolution of the historical centre of Kraków. Various historical documents related to the history, evolution and conservation of the urban fabric of Kraków's historical centre are referenced in the system. In line with Stenvert¹² those documents are described using:

- standard data identification - describing what the document is (author, edition, type of media, technique, etc.) used as description mode in the libraries for example.
- interpretation of data-content describing what the document is about (what does it show, etc.), used mainly in artistic and architectural analyses.

The approach presented here is based on a general observation of the roles that a representation plays in the study of historical architecture - it is in the same time a way of thinking and a method of communication. Consequently the types of representation that one uses depends on the information one wants to provide.

One input several outputs

The implementation we propose is based on a principle at the heart of XML related developments: one input-several outputs. 3D scenes are dynamically created as an answer to a query. The represented objects are given an appearance stemming from our knowledge. The graphic codes used in 3D scenes interpret the content of the database (VIA).

The scenes may show the town in a chosen moment in time (ex. the year 1790) (see Fig. 11) or display an overall evolution of an object (timeline scenes, where an interactive cursor of a VRML scene permits to choose a required date). Each identified evolution of an object is characterised not only by a particular morphology, but also by its localisation (that can change in time – on x, y, or z) as well as a specific typological information.

Each 3D scene is displayed with client-side interaction disposals that let a user to choose which database should be queried (VIA, SOL2, etc.) or what document type is available on the object.

Each object is displayed natively with a translucency that indicates the precision of the dating and with a colour codes indicating whether the represented morphology can be considered as a shape of the object at that particular date (date of the query) or whether it is a copy of a previous or later evolution of the object, thereby underlining needs for further investigation. Once the scene is displayed, other possibilities are left for the user (ex. the highlighting of objects in relation to types of documents as described in the documentation database).

Note 12. see R. Stenvert, “Constructing the past: computer-assisted Architectural-Historical Research”, doctoral thesis, University of Utrecht, Utrecht 1991

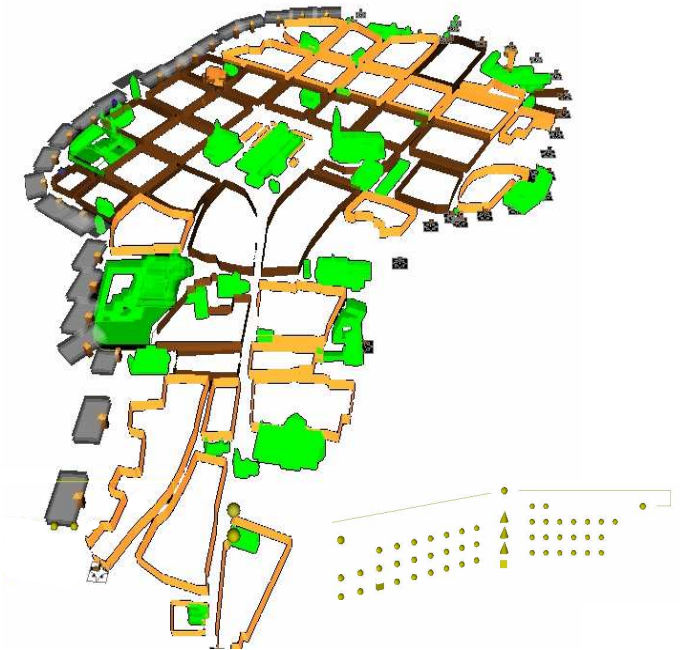


Fig. 11. Highlighting of objects used to visualise those for which this or that type of document exists. . Interactive buttons (bottom right) nested inside the 3D VRML model allow users to check for each type of document (for instance surveys, drawings, paintings, etc.) which objects do have a documentation that includes this type of document (in the example digital cartography).

A 3D scene can be also constructed in relation to a particular document. (see Fig. 12)


SOL Documentary Sources found for Object 586 (selection date: 1862)

Documentation specifically concerning the selection date

Number of answers : 1

Item 1 (extract from table Source)

MI_Idso	VC_Authors	VC_Title
58	IgnacyKrieger,	Kościół św. Barbary i klasztor Jezuitów



VC_Authors
LIKE

VC_Title
LIKE

SET_Media
LIKE

E_Support
LIKE

General constraint (for all conditions):
 AND
 OR

Choice of reference date To get Elements
 Request Cancel

Search

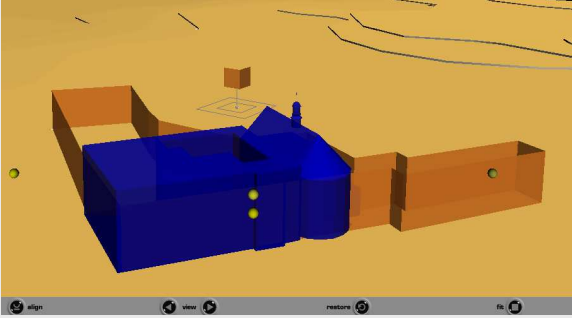


Fig. 12. In order to retrieve documents, for example a photograph (in this example a 1862 picture by Ignacy Krieger), a user specifies an author, a title and a date (the date when the picture was taken). The corresponding 3D scene is calculated as the answer to the query. All the architectural objects visible on the picture are represented in a 3D scene using the codes that describe the actual state of knowledge about them. The 3D scene allows then a search for all other documents related to objects visible on the picture, archival texts for example. In other words, starting from the selection of one document, users can learn “what else is known about this piece of territory”

Publications related to the experiment:

- J.Y. Blaise I. Dudek, *3D models as visual interfaces for Internet: an application to a multimedia documentation on architectural evolutions* Proceedings ICCVG '02 Conf., Zakopane, PL, 2002, ISBN 83-9176830-9, pp. 250-256-09)
- J.Y. Blaise I. Dudek, *New experimentation of a generic framework for architectural heritage data visualisation* Proc. WSCG 2003 Conf. (Winter School of Computer Graphics), Plzen, Czech Republic, 2003, Journal of WSCG vol 11 n°1, ISSN 1213-6972, pp. 109 – 117
- J.Y. Blaise I. Dudek, *Dynamic Representations for Information Visualisation and Retrieval: a Case Study on Kraków's Architectural Heritage* Proc. ITI 2004 (Information Technology Interfaces), Cavtat, Croatia, 2004, pp335-340, ISBN 953-96769-9-1
- J.Y. Blaise I. Dudek, P.Bénistant, A.Durand, *Online 2D/3D graphic interfaces using XML “repurposable” heritage contents*, Proc. WSCG 2004 (Winter School of Computer Graphics), Plzen, Czech Republic, 2004, Journal of WSCG vol 1 ISBN 80-903100-5-2, pp. 39 –46
- J.Y. Blaise I. Dudek, *From artefact representation to information visualisation: genesis of informative modelling* Proceedings of 8th Smart Graphics International Conference, (2005) (2005) 230-236 Springer, LNCS 8th Smart Graphics International Conference (2005-08) (2005) Germany ISBN 978-3-540-28179-5
- J.Y. Blaise, I. Dudek, “*Règles d'identification et méthodes de visualisation d'objets architecturaux?*”, proceedings: EGC'2004, Clermont Ferrand 200 , ISBN: 2.85428.633.2, Vol. II, pp. 573-584

Planes and visual language

As mentioned in section 3.1.2, 3D models are sometimes ill-suited to an efficient visualisation of information. As T. Pratchett writes : *Our mind is not able to grasp the world as it is. We operate with simplified representations of it's fragments. Simplicity of the clear-cut le models helps us in better understanding.*

The choice of representation mode one uses should not be a question of a fad or enthusiasm for a trendy technology. 3D is not always appropriate way to present information. Planes are sometimes more successful in delivering information.

Another important point is the biggest possible language independence. In other worlds we should switch, as often as it is possible, from the ethnical languages to a visual language – using more abstraction and more semantic codes. Switching to visual language provides more explicitness and clear-cut nature of concepts. It does not mean at all, that the use of ethnical languages and textual representations should be abandoned – they are necessary and very useful - but not always efficient in a concise transmission of information.

In the following experiments we present 2D graphics, created from the same set of 3D data as this used in the previous section. Graphics are here designed as means to visualise the relation of documentary sources to the places and time slots the sources help documenting. In other words, graphics show what can be understood as the “architectural content” of the historical sources. By architectural content of a historical source we understand an ensemble of information concerning architectural (or urban) elements one can derive from a source (*i.e.* represented objects, date(s) at which they are represented).

Fig 13 illustrates the basic application of this principle: since we have linked to elements of architecture various sources, we can also use the link the other way round and provide a spatial distribution of the sources' content. Accordingly, the architectural content of a source, or a set of sources, will be represented as sets of architectural elements distributed in the space of the model, and in the corresponding time slot. Colour coding identifies main architectural typologies and helps underlining fields of interest of a document, of areas of investigation of an author. It is clear that this feature of the VIA / SOL2 - Knowledge management and visualisation platform would hardly benefit from a 3D representation. 2D is here not only enough, but faster and clearer to read. Naturally, selection of elements of architecture displayed in the 2D visual disposal relates it to other information sets and other representation modes (including 3D) available in the system.



Fig. 13. Architectural content of an author's publications : (top) – XIX c. painter; (bottom) - XIX c. architect (narrow ontological coverage - only monumental buildings, but throughout the city)

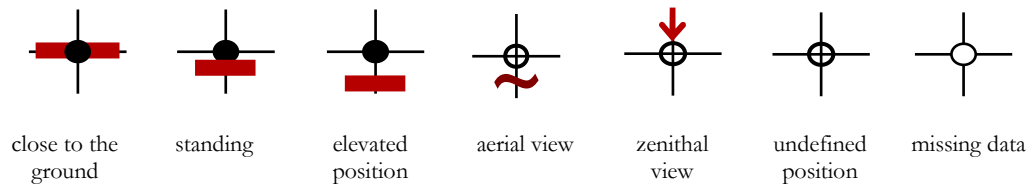
Spatial location of the historical visual sources

Among the sources we deal with when studying an artefact's evolution, there are a number of visual sources that may be unprecise in terms of geometry (hand sketches, paintings, etc.) but that provide vital clues in the understanding of the artefact's morphology. Once works presented in the previous section were concluded, we soon came up with the idea of giving users means to query the system like in this example: "find all the illustrations showing the north-east side of artefact A". The question is a simple one. However the implementation of a practical computer-based solution is tricky when dealing with sources for which nothing like "GPS coordinates" will ever be available.

So by a "spatial location of the historical visual source" we understand here an ensemble of view determining parameters. This category is obviously difficult, if not impossible to be implemented to texts. Therefore we considered that the textual sources will not have this type of description. Generally speaking texts shall be treated separately.

The determination of a view determining parameters is neither simple for visual sources. The necessary parameters are :

- a position of a viewer (x,y,z) with a coefficient of precision (for many historical sources it is very difficult - if not impossible - to determine precisely the position of viewer) and a special treatment of a z co-ordinate – the definition of which poses equally multiple problems (see Fig. 15);



- a target of the view, that may be defined by a point or using what we called a bearing – in other words a horizontal angular direction of view. A Bearing can be alternatively replaced by a geographical bearing, defining the general geographical orientation (cf. Fig. 14).
- or some visual sources it may be useful to provide also a vertical bearing – a vertical angle of view (cf. Fig. 16).

Besides, the artists use quite often the sketches to prepare their final works. From various reasons (*i.e.* panoramic views) they draw them from different points. In those cases, a resulting representation can not be described by only one point-of-view and one view-direction. A mono-

Publications related to the experiment:

J.Y. Blaise I. Dudek, *Visual tools decipher historic artefacts documentation*, Journal Of Universal Computer Science, (2007) (2007) 456-463 Know-Center J.UCS I-Know 2007, 7th International Conference on Knowledge Management, KVD Workshop (2007-09) (2007) Autriche ISSN 0948-695x
 J.Y. Blaise I. Dudek, *Beyond graphics: information An overview of infovis practices in the field of the architectural heritage* Proceedings of the GRAPP 2008 International Conference, (2008) 147-150 INSTICC PRESS GRAPP 2008, Third International Conference on Computer Graphics Theory and Applications (2008-01) (2008) Madeira Portugal ISBN 987-989-8111-20-3

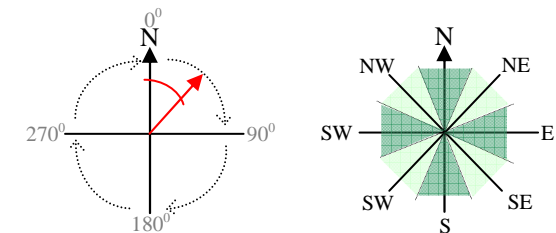


Fig. 14. Spatial location of a visual document - bearing and geographical bearing, [ATIP 2007]

Fig. 15. Architectural content of a document - viewer's estimated position. [ATIP 2007]

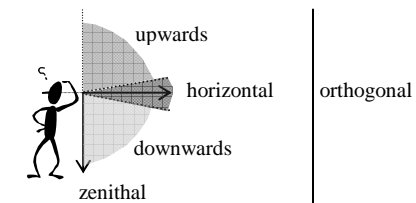


Fig. 16. Spatial location of a visual document - vertical bearing [ATIP 2007]

and multi- point-of-view representation have to be considered separately. Consequently, two different types of description and representation of a source spatial localisation were provided (see Fig. 18).

Implementation

VIA / SOL2 technological choice does not stress one technology but investigates a possible combination of formalisms: OO modelling, XML, Interactive VR modelling basing on open standards, VR scenes / e-databases interfacing. The choices we introduce can probably be better understood in the light of the followed guidelines:

- Autonomy of 3D models and textual results with regards to the application that gave birth to them,
- Interactive visualisation of 3D models on the Web,
- 3D models stored in a format that can be manipulated with a standard programming language,
- 3D models used as graphical interfaces that provide a connection various data sets (ex. RDBMS, another 3D model, text, etc.,
- Use of existing RDBMS structure for the documentation itself.

Observations and conclusions

- In studies on the architectural heritage, data management raises non-trivial interfaces issues, notably due to the quantity, diversity, complexity and heterogeneity of the data to manipulate. 3D representation appears as one of the possible answers to this problem since it localises defined concepts spatially, permits to give them a form and to link a set of information to them.
- 3D models of the architectural objects are a natural and efficient filter for data visualisation and retrieval. A central improvement in the actual practice is the fact that architectural data finds its natural media – shapes.
- From the point of view of the documentation, benefits of such development include the possibility to visualise what a selected document is about, the possibility to compare the quantity and quality of information for various zones or objects types, etc.
- The use of architectural and urban elements allows the architects to build scenes using their own concepts, rather than the concepts of geometry. It allows an author of a reconstruction to represent his/her own doubts concerning particular objects.

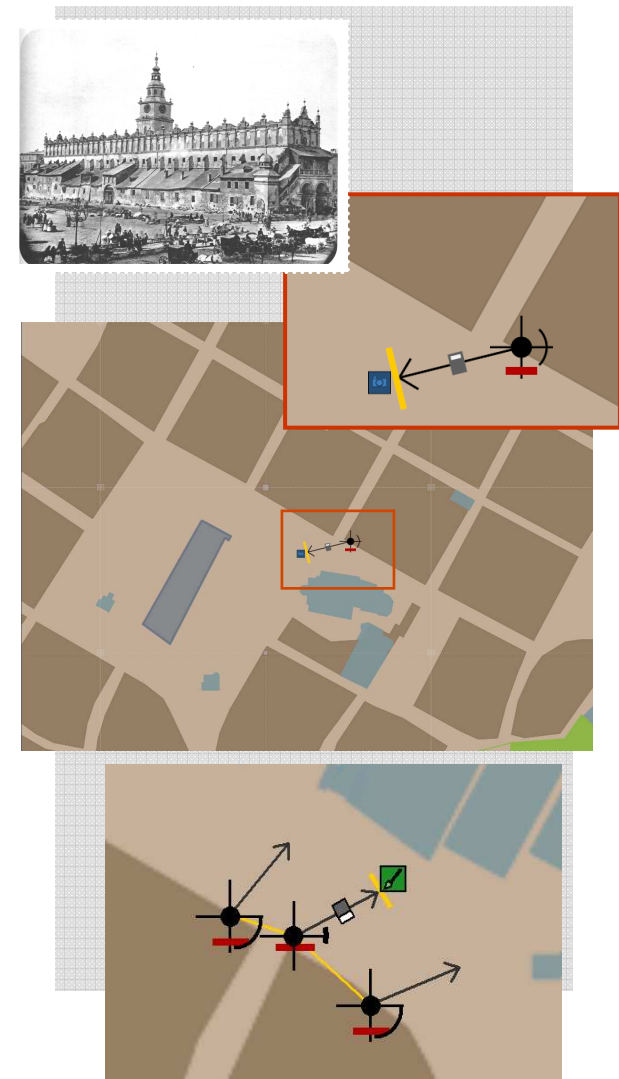


Fig. 17 Spatial contextual visualisation
top - symbol corresponding to the top left photography;
bottom - visualisation of a multi-point-of-view (artistic representation).

- The experience with VIA / SOL2 system has revealed its capacity to help in pointing out the questions that remain to be raised, or that are only partly addressed. The provided 3D scenes may help the researcher to visualise in a clear and simple way a state of knowledge on an urban complex evolution. They can be therefore considered as beneficial means of visualisation since they show what is known and underlines what is not known.
- One of the objectives of a visualisation in our application domain should be the better documentation readability and access. This requires a step of interpretation.
- The conducted research demonstrates that it is possible to greatly enrich the usefulness of 3D representations under condition that more attention is put to the semantics of representation. This question opens a research area that needs more involvement. At the actual state of advancement presented works provide an operational framework for the capitalisation (through database and XML formalisms) of this interpretation phase during which researchers establish meanings of raw data, and that derives possible scenarios of morphological evolution. Although the documentation analysis step is a costly one, it is a vital one in this particular application domain. It provides services in terms of readability and updatability that we think greatly enrich the usefulness of 3D representations.

Naturally this experiment also has raised questions that remain to be further developed, and notably:

- Generic morphological definitions shared by various objects could be developed, in a way applying the XML paradigm in a yet-to come Architectural Modelling Language.
- Further investigations of graphics readability issue are necessary.

VIA/SOL2 contribution should be considered as a first step in efforts of using 3D modelling in the semantic visualisation of interrelated spatio-temporal data sets on archival information. It confirms the necessary operational division between, on hand hand - 3D data as a feature of a semantic-rich broder concept (here architectural elements), and on hte other hand - 3D / 2D visual duisplays exploiting part or whole of this data in an information search, retrieval and visualisation context. In other words, it simply applies to 3D data related to architectural artefacts the XML paradigm : one input – *the artefact and its spatial and temporal features* , several outputs – *visuals disposals benefitting from the spatial and temporal information distribution the input allows*.

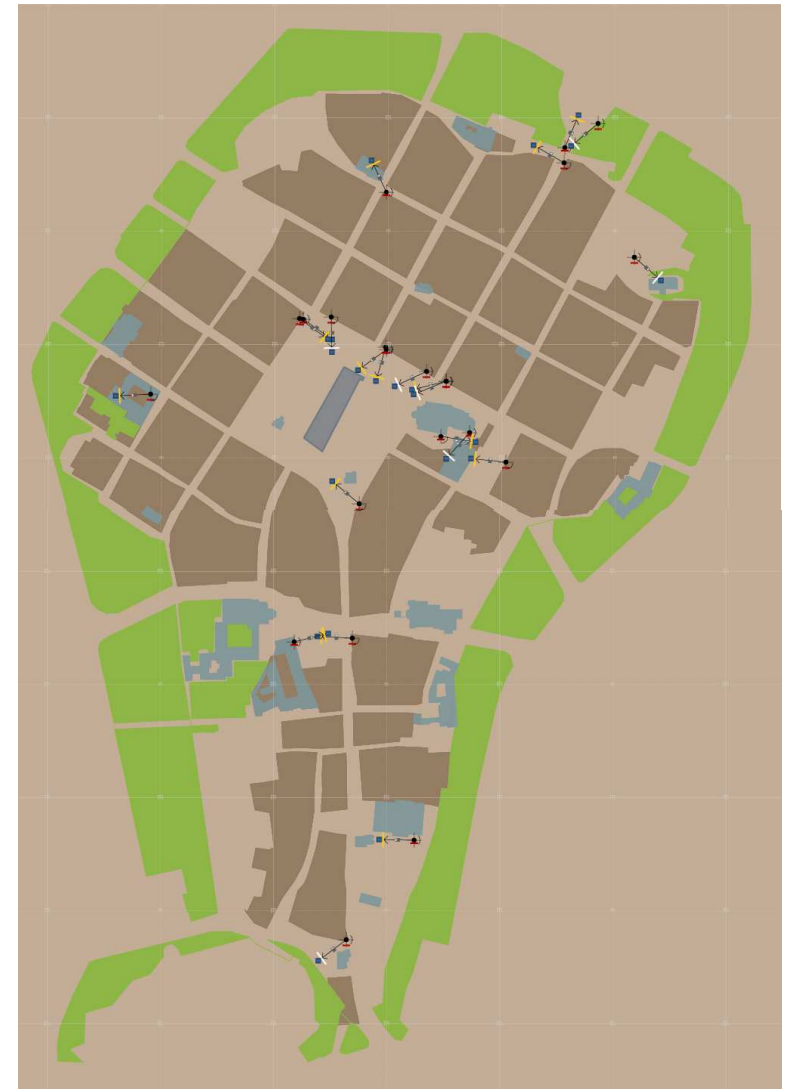


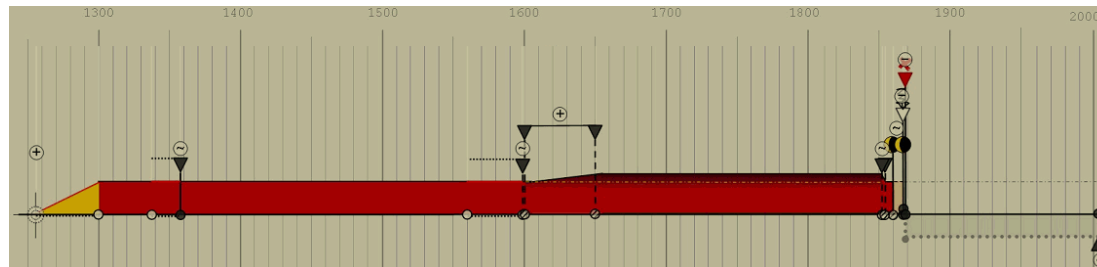
Fig. 18. Source localisation by authors – Ignacy Krieger viewer's estimated position. [ATIP 2007]

3.3 - Distributing information in time

In sections 3.1 and 3.2 we have presented how we use 3D data - understood as a feature of architectural objects - in order to distribute in time and space pieces of information. As a result, pieces of information related to the evolution of artefacts are available through various visual disposals - in 2D or 3D depending on the amount of abstraction needed for best readability – created dynamically by methods reading the same set of XML-formatted 3D data.

It is important to say- although we will do it very briefly - that the visual disposals we have presented have one point in common: they privilege space over time, and thereby hide time dependant information like densities of changes, or duration of changes. Accordingly we have in a recent research introduced a methodological framework aiming at describing life cycles in heritage architecture, in what can be seen as a diachronic approach. Focus is put on the way artefacts get transformed, with a grid of notions identifying life cycles as a sum of states and transitions. We then introduced diagrams that act as visual explanations of the artefact's life cycles: they foster a comparison-enabled, global vision of the artefact's evolution; whereas traditional architectural representation (and notably 3D CAD based), by privileging shape modelling, tends to enhance states over changes.

To say it briefly, we believe that when talking about the issue of 3D data and models in heritage architecture, it is also important to say where its weaknesses lay. At the end of the day, we need to state that historic artefacts *are not* a 3D phenomenon: they are a 4D phenomenon. And so the cost of acquiring and manipulating 3D data about artefacts should also be analysed with regards to what remains to be done afterwards, what remains to be assessed visually by means of space-freed visual displays. As analysts of architecture, we consider that, more than 3D itself, a better integration of space and time within visual disposals is today a key research issue, in the legacy of Minard's figurative maps¹³.



Publications related to the experiment:

J.Y. Blaise, I. Dudek, *Profiling artefact changes: a methodological proposal for the classification and visualisation of architectural transformations*, [in] Digital Heritage, Archeolingua, Budapest 2008, ISBN 978-963-8046-99-4, pp. 349-356

J.Y. Blaise, I. Dudek, *Visual assessment of heritage architecture life cycles* Journal Of Universal Computer Science, (2008-09) (2008) 349-357 Know-Center J.UCS I-Know 2008, I-Know I-Media 08, 8th International Conference on Knowledge Management (2008-09) (2008) Graz Autriche ISSN 0948-695x

Note 13. see

Friendly, M, 1999. Re-visions of Minard, Statistical computing and graphics newsletter, Vol 11, n° 1.

Tufte, E.R., 1997. Visual explanations. Graphic Press, Cheshire.

Tufte, E.R., 2006. The visual display of quantitative information. Graphic Press, Cheshire.

Tufte, E.R., 2006. Beautiful evidence. Graphics Press, Cheshire.

J.Y. Blaise, I. Dudek, *Experimenting timelines for artefacts analysis: from time distribution to information visualisation* [in] Digital Heritage, Archeolingua, Budapest 2008, ISBN 978-963-9911-00-0, pp. 197-204

Fig. 19. The diachrogram - a visual disposal presenting the evolution of an artefact along a time axis. Diachrograms are composed of a set of visual indicators representing successive transitions and states combined into life cycles. [ATIP 2008]

3.4 - Investigating Metaphors

Visual metaphors are what W.Kienreich¹⁴ identified as one of the *fundamental units of visual representation available to a designer*. Visual metaphors base on real-world equivalents to display information. Visual metaphors use analogies, and thereby rely also on intuitive behaviours. Consequently, they often require careful evaluation in order to judge of their efficiency in terms of information interfacing. As noted by the author, when drawing a visual metaphor, the 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*. A lot has been done and written about visual metaphors, notably in the field of information visualisation, and Lengler's "Periodic table of visualisation methods"¹⁵ (itself a metaphor, by the way) gives a good overview of their potentials uses, and relations to other visualisation methods.

In most cases, visual metaphors rely on real-world equivalents that are used figuratively. A good example is the well-known family tree metaphor: children do not grow on branches, the tree is a figurative representation of parent/child relation. But visual metaphors can be used in the literal way: in Göbel's GeoLibrary¹⁶ a 3D virtual edifice acts as a library, with documents stored in drawers like in the real world. Users meander in the edifice in order to locate the storey, the room and the drawers they came to "borrow".

Experiments reported in previous sections use *literal real-world equivalents*¹⁷: the representation of the artefacts (in 2D or 3D) stand for the artefacts themselves. But we have also in recent developments experimented *figurative real-world equivalents*. Choosing a figurative real-world equivalent means for the designer trying to find an "image" that best matches the information to deliver. Visual metaphors that rely on figurative real-world equivalent are omnipresent in communication, with questionable results sometimes when the image is not shared by the audience targeted. Many architectural or urban spaces have been (and still are) used as figurative real-world equivalents, for instance in Russo Dos Santos' metaphoric worlds¹⁸ where a virtual 3D city supposedly represents the various parts and elements of a computer.

We hereafter briefly present two experiments where 3D displays act as metaphors helping users to browse inside information systems.

3.4.1 The Infosphere disposal

Infosphere is an experimental visual disposal aimed at sorting out and at giving access to documents about an artefact under scrutiny. Documents are visualised and retrieved inside a 3D interface that combines two metaphoric figures: the artefact itself and a "looking_like geographic" globe. The disposal bases on the hypothesis that for each document in a data set a

Note 14. Kienreich, W., 2006. Information and Knowledge Visualisation: an oblique view, *MiaJournal*, Vol. 0, pp. 7-16

Note 15. Lengler R., Eppler M., 2007. Periodic table of visualisation methods, <http://www.visual-literacy.org/> (accessed 23 Jun 2008).

Note 16. Göbel, S., 2003. *GeoLibrary: Metaphor-based Information and Navigation Space to Access GeoData Archives*, In : Proc. I-Know 03 Conference, JUCS/ Graz, pp. 121-127.

Note 17. J.Y. Blaise, I. Dudek, *Infosphere: one artefact, two metaphors, three sort criteria* [in] Digital Heritage, Archeolingua, Budapest 2008, ISBN 978-963-9911-01-7, pp. 362-367

Note 18 Russo Dos Santos, C., et al., 2001. *Dynamic Information visualisation Using Metaphoric Worlds*. In : Proc. VIIP 2001, Marbella, pp. 60-65.

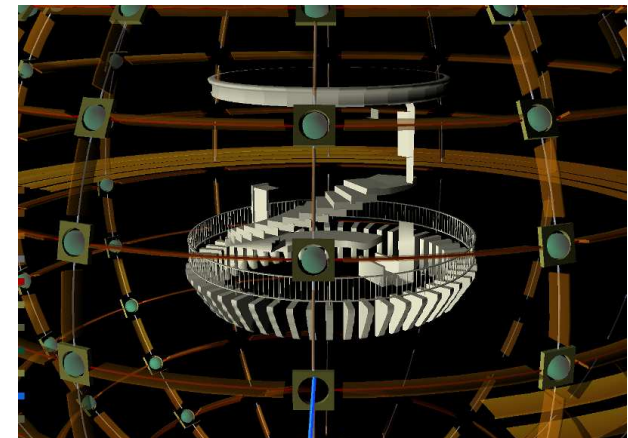


Fig. 20. A literal real-world equivalent: the decomposition of the signal tower in sub parts identifies the level of detail of the documents available.

corresponding element of the artefact under scrutiny can be found (edifice as a whole, parts, details, etc.).

Infosphere is designed as a tool helping to sort out, visualise and retrieve documents concerning an artefact, according to three parameters: granularity of the architectural analysis, level of abstraction of the documents, and time slot concerned.

Documents are positioned inside a 3D metaphoric display by an $[x,y,z]$ triplet (materialised in the 3D interface by the intersection of parallels and meridians of a sphere); where $[x]$ corresponds to a breaking down of a site into sub-elements (spatial granularity, more or less equivalent to level of detail), $[y]$ corresponds to the level of abstraction of the documents itself (from realistic representations to diagrammatic analyses), and where $[z]$ corresponds to a given time slot (changes in the sphere's diameter correspond to different time slots). Accordingly, the disposal sorts out and distributes information and documents using three criteria:

- To which discrete element (*i.e.* ~ level of detail) does the document correspond? (what we will call in the figure legends spatial granularity)
- What is the level of abstraction (*i.e.* ~ of human interpretation) of the document?
- What is the time slot shown ?

At each x,y,z intersection an event-sensible intersection point is positioned, represented by a square and a sphere. The sphere is used to select an x,y,z intersection and to download the corresponding model of the signal tower (illustrating the spatial granularity for this intersection). In addition, a click on the intersection point's sphere opens a blue line that helps the user know "where he is". Finally, along this blue line all the other intersection points corresponding to different periods are displayed for the user to see whether or not there are information corresponding to his [level of detail, level of abstraction] selection for other periods.

The display is composed of two visual metaphors. The artefact itself is represented as a 3D metaphoric model positioned at the centre of the scene. A sphere based on a second metaphor (parallels/meridians of a globe as represented by geographers) encircles the artefact's model.

The disposal is tested on the "signal light tower" in Marseilles, erected during the XVIIth century as a part of the fortification barring the entrance to the city's port, and serving as a lighthouse.

Although clearly an experimental disposal (with a number of limitations), Infosphere does put to the fore that 3D in itself can be a possible figurative metaphor used to distribute pieces of information with regards to triplets of search criteria. No other claim than this one should be understood from this experiment.

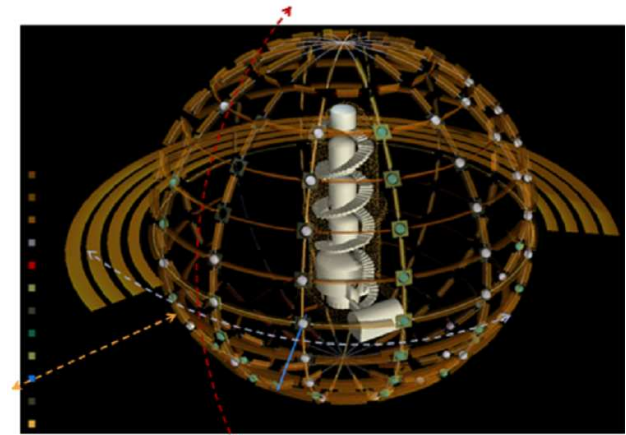


Fig. 21. The three axis of the globe metaphor, and at the centre of the disposal the artefact as literal real-world equivalent.

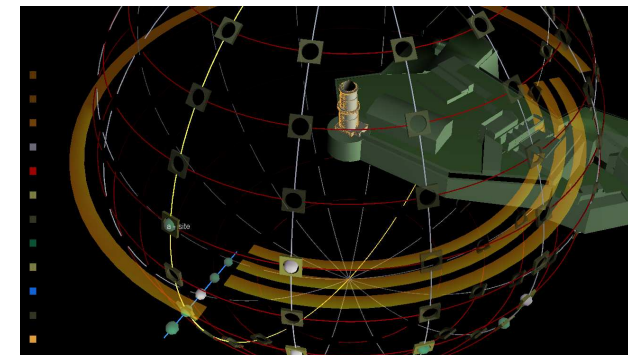


Fig. 22. Selection of an intersection point corresponding to the 1644-1668 period, with a number of inactive intersection points (absence of documents). In the case illustrated here, x- spatial granularity whole sites, y- level of abstraction plaster models, B&W graphics, z- time slot 1644-1668. Note, left, a column with coloured square: each of them corresponds to a graphic variable that users can interactively turn on / off.

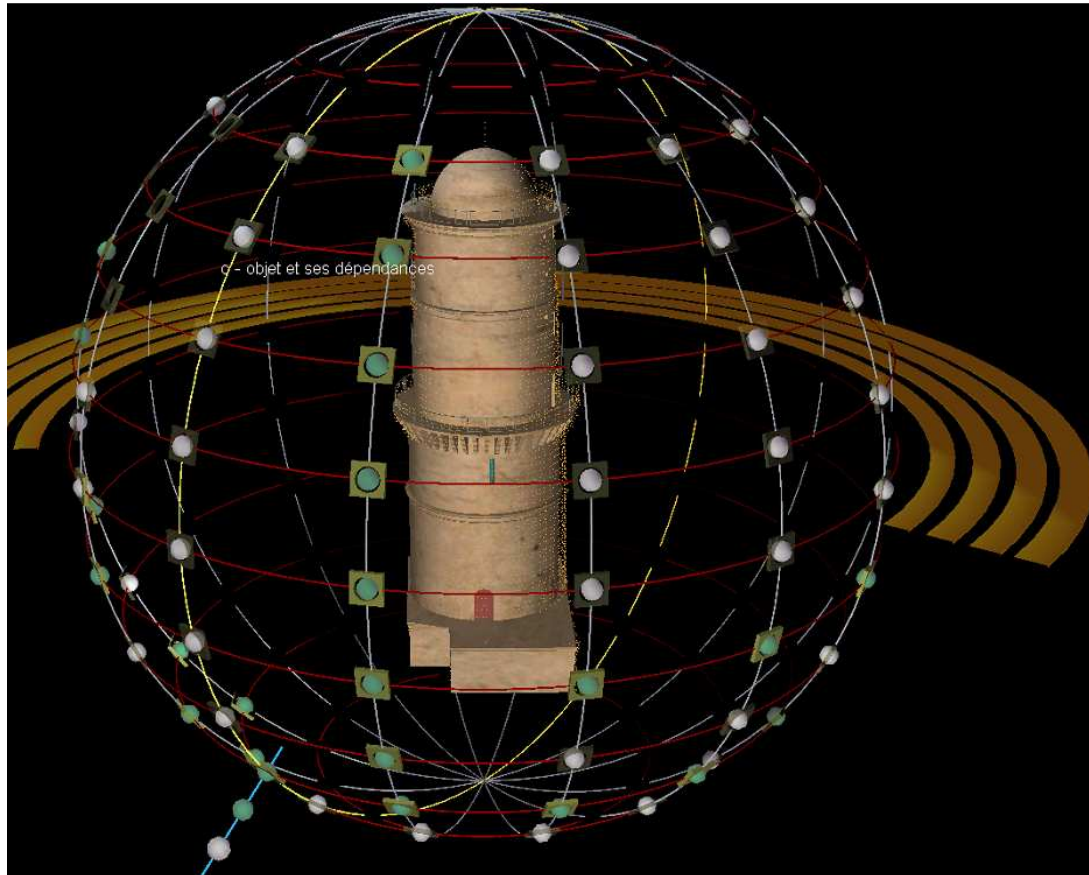


Fig. 23. A screen capture of Infosphere. Note, in blue, meridians (x axis, level of detail), in red, parallels (y axis, level of abstraction) and rings to control z axis (diameter of the sphere, time slot). By selecting an x,y,z triplet (done by a click on an intersection-points), the user opens the blue line, (bottom left of the image) and interactively downloads a model of the tower acting as a metaphor for this x,y,z triplet. In the case illustrated here, x-spatial granularity artefact and its dependencies, y- level of abstraction raw photographic material, z- time slot present times. Highlighted in yellow by an onmouseover event, the selection's corresponding meridian.

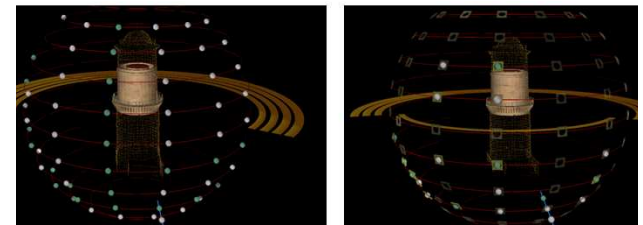


Fig. 24. Beyond sorting out and giving access to documents, gaining a global vision of our documentation: a comparison of the net of documents we have for the present times (left) with the net of documents we have for the previous relevant period (XIXth century)

3.4.2 The UIA XXth century heritage web interface

The UIA (International Union of Architects) has asked us to create an information system on the web dedicated to the XXth century architectural heritage¹⁹. This *XXth century architecture web repository* is open for contributions to the various national sections of the UIA. Accordingly, we have tried to provide a set of ethnic-language free visual tools that would allow a visual browsing of the system. Metaphors are this time not used in order to deliver information

Note 19. For a full description of the context, goals and partners of this initiative see the system's web site online :www.archi.fr/UIA

directly, but as a mean to find one's way inside the system in a way that resembles edutainment activities. Although clearly a minor contribution in terms of research, this experiment shows that 3D understood as a metaphor can if not supplement, at least complement traditional browsing modes such as lists, menus, etc.. In other words, there is probably more to using 3D (in the context of information search retrieval and visualisation) than mimicking the geometric “reality” of an artefact, like there is more in a map than the territory itself.



Fig. 25. The System's navigation top bar with, right, a figurative real-world equivalent used to select query modes.

4 - Conclusion

In this contribution we have tried to present examples showing where, how, and with what limitations 3D fits in a more global scientific context: handling information in the context of historic architecture. In that context, it is necessary to clearly distinguish the handling of 3D data itself, and the use of various visual disposals (3D or not, metaphoric or not) that help gaining a global vision of an artefact's evolution. Our approach has been established to meet a dual need:

- to make architecture a spatial and temporal filter through which layers of heterogeneous information can be brought together, such as measurement and documentation;
- to use digital models as iterative information visualisation tools, constructed and reconstructed from day to day as answers to questions, and aiming to be what the map is to the representation of territories.

Acquiring and archiving 3D data then appears as an issue that can only be dealt with once relations of the data to the proper semantic layer – *i.e.* architecture- have been assessed. Our contribution shows that 3D can be *one of the means* to distribute of pieces of information in time and space. It however, at this stage, and because of the difficulty to “*go abstract*” in 3D, somehow poorly assists the reasoning on information sets. The use of metaphors, and a better integration of space and time within visual disposals, appears as potentially fruitful research directions.

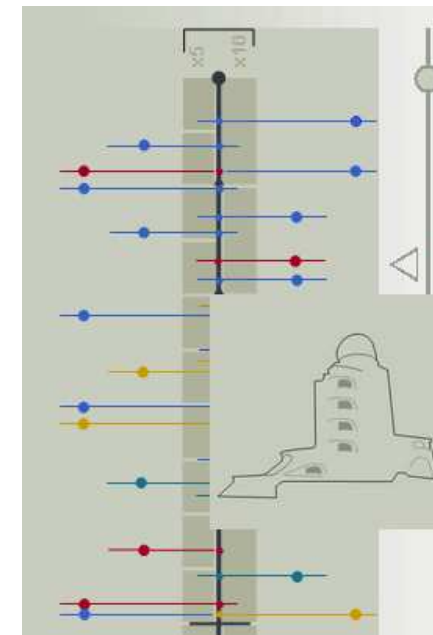


Fig. 26. The System's navigation and visualisation timeline: coloured lines and dots dispatched on the left and right sides of the line identify 48 reference buildings to which an edifice under scrutiny can be compared to (vertical line on the right). Brownish rectangles are used to query the database on 5 or 10 years intervals.

References

- [1.] J.P. Saint Aubin, “*Le relevé et la représentation de l’architecture*“, Service de l’Inventaire Général, éd. Documents & Méthodes, Paris 1992
- [2.] J.Y. Blaise I. Dudek, “*SOL : Spatial and historical web-based interface for On Line architectural documentation of Kraków’s Rynek*“, eCAADe, Liverpool 1999, pp. 700-707
- [3.] J.Y. Blaise, I. Dudek, “*Interpretative modelling as a tool in the investigation of the architectural heritage: information and visualisation issues*“, VIIP 2001 Marbella 2001, pp. 48-54
- [4.] J.Y. Blaise I. Dudek, F. De Domenico, “*Spatial distribution and visual analysis of architectural semantic features*, Journal Of Universal Computer Science”pp. 498-506,
- [5.] J.Y. Blaise I. Dudek, “*3D models as visual interfaces for Internet: an application to a multimedia documentation on architectural evolutions*“, ICCVG ’02, pp. 250-256-09
- [6.] J.Y. Blaise I. Dudek, “*New experimentation of a generic framework for architectural heritage data visualisation*“, Journal of WSCG vol 11 n°1, ISSN 1213-6972, pp. 109 –117
- [7.] J.Y. Blaise I. Dudek, “*Dynamic Representations for Information Visualisation and Retrieval: a Case Study on Kraków’s Architectural Heritage*“, ITI 2004, Cavtat, pp. 335-340
- [8.] J.Y. Blaise I. Dudek, “*From artefact representation to information visualisation: genesis of informative modelling*“, Springer 2005,
- [9.] J.Y. Blaise, I. Dudek, “*Règles d’identification et méthodes de visualisation d’objets architecturaux*“, EGC’2004, Clermont Ferrand, ISBN: 2.85428.633.2, Vol. II, pp. 573-584
- [10.] J.Y. Blaise I. Dudek, “*Visual tools decipher historic artefacts documentation*“, Journal Of Universal Computer Science, pp. 456-
- [11.] J.Y. Blaise I. Dudek, “*Beyond graphics: information An overview of infovis practices in the field of the architectural heritage*“, GRAPP 2008 pp. 147-150
- [12.] J.Y. Blaise, I. Dudek, “*Profiling artefact changes: a methodological proposal for the classification and visualisation of architectural transformations*“, [in] Digital Heritage, Archeolingua, Budapest 2008, pp. 349-356
- [13.] J.Y. Blaise, I. Dudek, “*Visual assessment of heritage architecture life cycles*“, Journal Of Universal Computer Science, ISSN 0948-695x, pp. 349-357
- [14.] J.Y. Blaise, I. Dudek, *Experimenting timelines for artefacts analysis:from time distribution to information visualisation* [in] Digital Heritage, Archeolingua, Budapest 2008, ISBN 978-963-9911-00-0, pp. 197-204
- [15.] Friendly, M, “*Re-visions of Minard*“, Statistical computing and graphics newsletter, Vol 11, n° 1.
- [16.] Göbel, S., 2003. *GeoLibrary: Metaphor-based Information and Navigation Space to Access GeoData Archives*, In : Proc. I-Know 03 Conference, JUCS/ Graz, pp. 121-127.
- [17.] Kienreich, W., 2006. *Information and Knowledge Visualisation: an oblique view*, MiaJournal, Vol. 0, pp. 7-16
- [18.] Lengler R., Eppler M., 2007. Periodic table of visualisation methods, <http://www.visual-literacy.org/> (accessed 23 Jun 2008).
- [19.] R. Stenvert, “*Constructing the past: computer-assisted Architectural-Historical Research*“, doctoral thesis, University of Utrecht, Utrecht 1991
- [20.] E. R. Tufte, “*Beautiful evidence*“. Graphics Press”, Cheshire 2006
- [21.] E. R. Tufte, “*Visual explanations*“, Graphic Press, Cheshire 1997
- [22.] E. R. Tufte, “*The visual display of quantitative information*“, Graphic Press, Cheshire 2006