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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

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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:

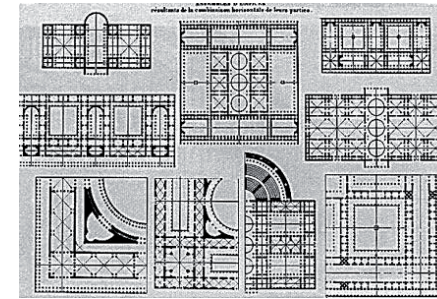


Fig. 2. Image from J.N.L.Durand's *Parallèle...*: juxtaposition of plans.

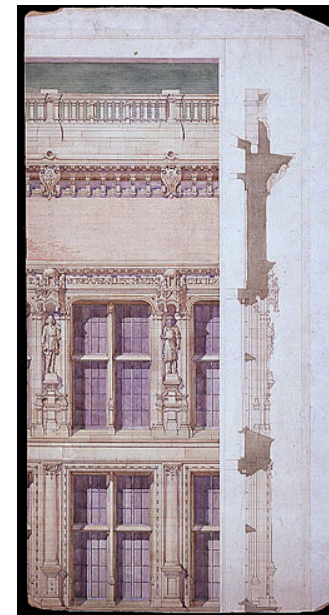


Fig. 3. Beaux Arts watercolor drawing with much detail.

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- 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.

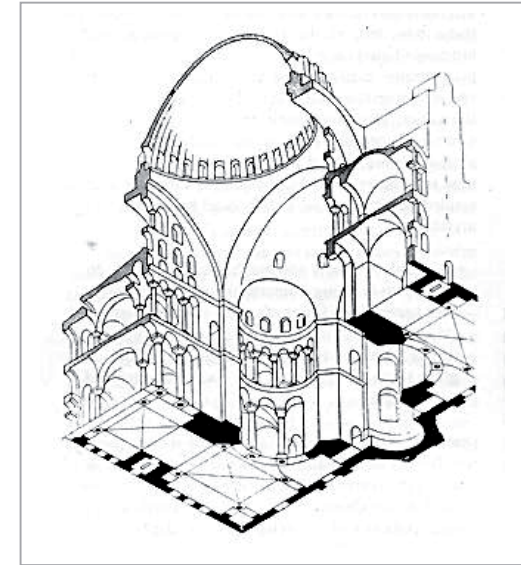


Fig. 5. Auguste Choisy: axonometric drawing.

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!

Heusden’s Map by Blaeu (1649)

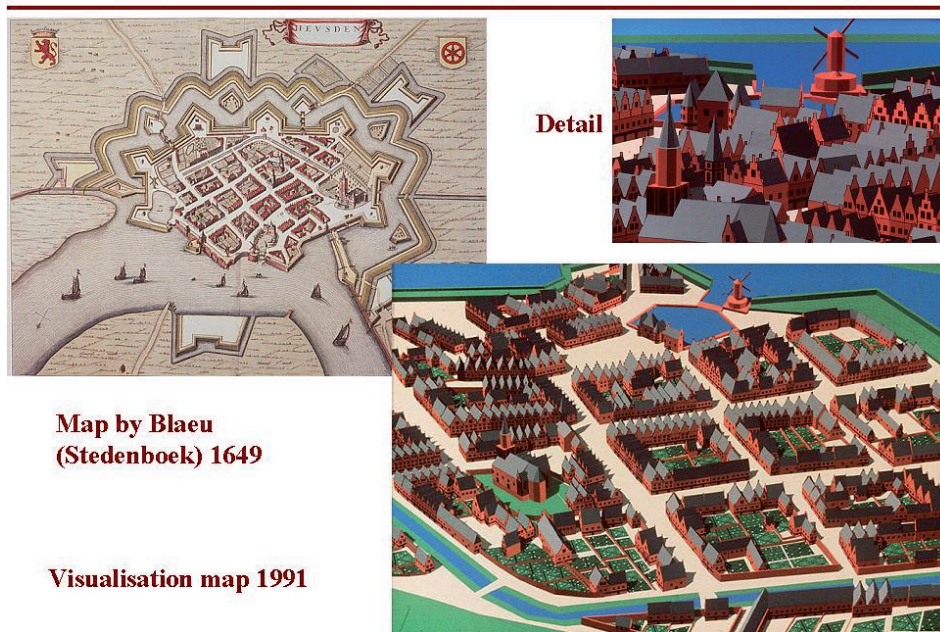


Fig. 6a. Photograph of the fortified town of Heusden The Netherlands (1990).

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

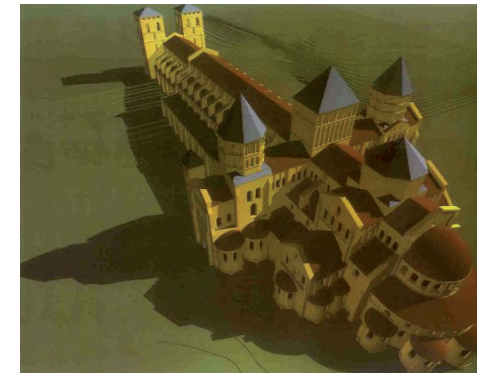


Fig. 7. Reconstruction of Abbey of Cluny: early research to its former appearance.

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

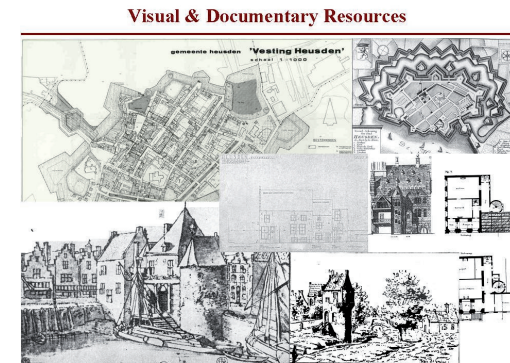


Fig. 8. Detailed drawings, maps and plans as sources for the 3D computer model.

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

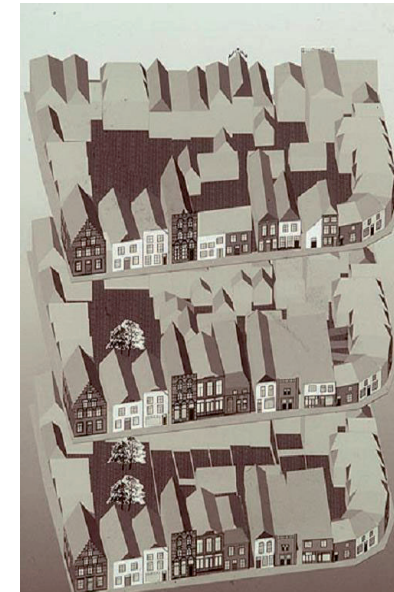


Fig. 11. Change Vismarkt Heusden 1900-1943-1990.

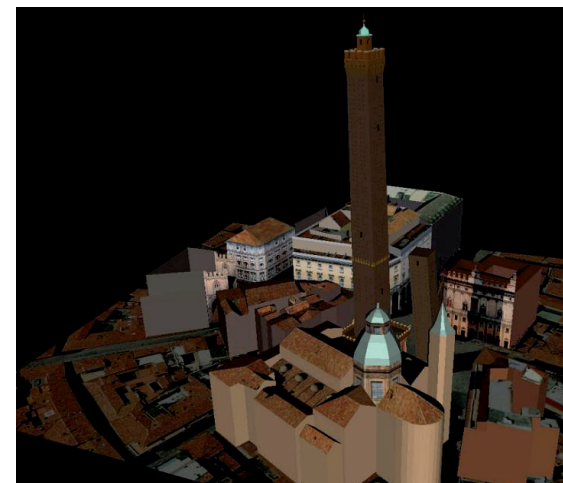


Fig. 12. NuMe: Bologna

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.

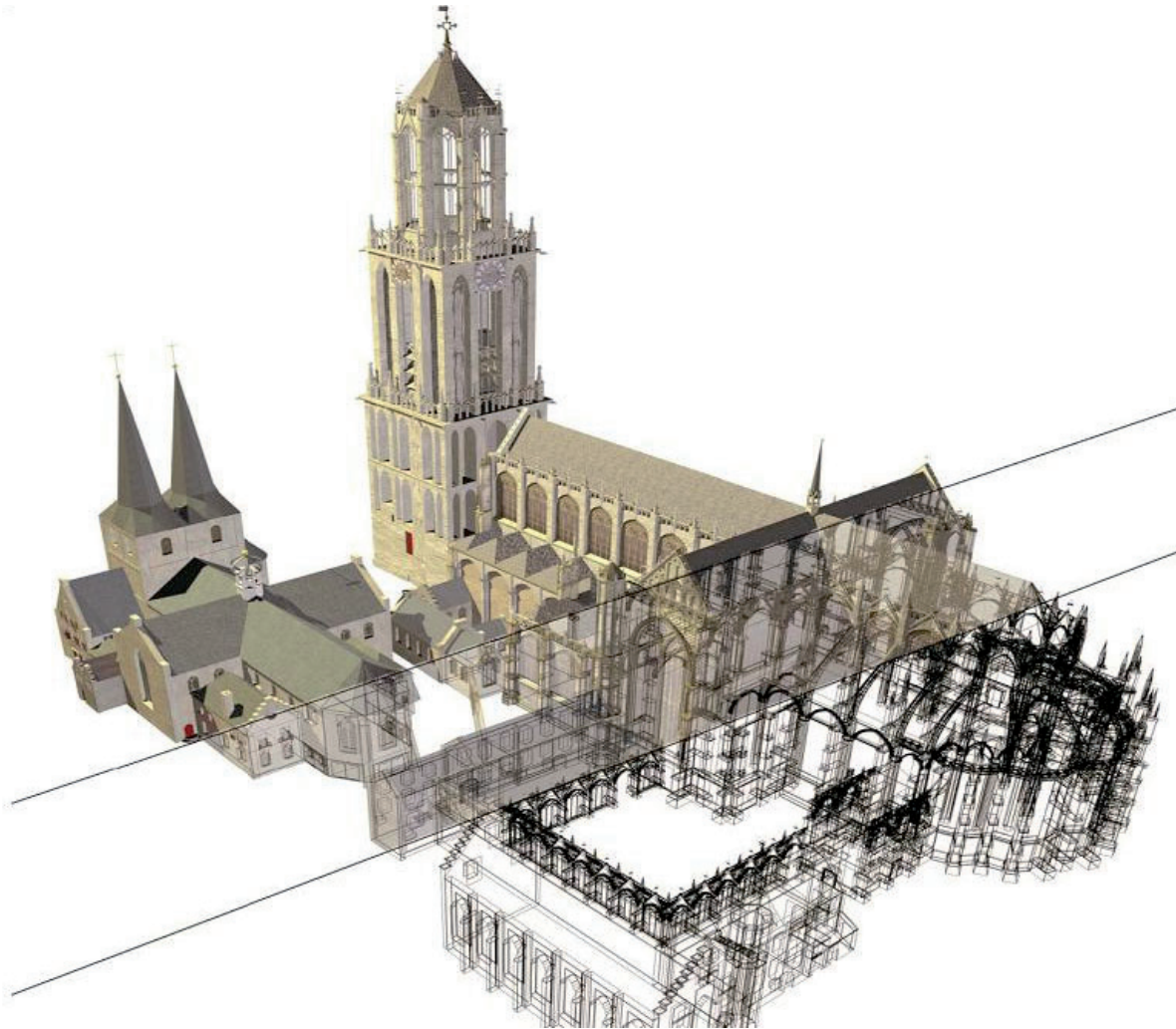


Fig. 13. Visualization of Dom Church in Utrecht, The Netherlands, by DeRode3D. The parts in wireframe have been destroyed.

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