36. The Reconstruction of the Past: the Application of New Techniques for Visualisation and Research in Architectural History

Patricia Alkhoven

Department of Architectural History
University of Utrecht
3512 HD Utrecht, The Netherlands

This paper focuses on the visualisation of historical architecture. The application of new Computer-Aided-Architectural-Design techniques for visualisation on micro computers provides a technique for reconstructing and analysing architectural objects from the past. The pilot project describes a case study in which the historical transformation of a town will be analysed by using three-dimensional CAD models in combination with bitmap textures. The transformation of the historic town will be visualised in a space-time computer model in which bitmap textures enable us to display complex and relatively large architectural objects in detail. This three-dimensional descriptive model allows us to survey and analyse the history of architecture in its reconstructed context. It also provides a medium for researching the dynamics of urban management, since new combinations and arrangements with the individual architectural objects can be created. In this way, a new synthesis of the graphic material can reveal typologies and architectural ordering systems of a town.

The historical project

Ever since Aldo Rossi's "The Architecture of the City", interest of architects and historians in the comprehensive analysis of the city has assumed enormous proportions (Rossi 1984). In search of design solutions, the history of the place (locus) and context is once more being taken into account. A successful urban development design presupposes a thorough knowledge of the city, its elements, its history and its dynamics. The city is to be conceived of as a collection of architectural 'facts' which can only be understood through an examination of the historical process.

The complex analysis of the dynamics of urban processes demands careful examination of the elements which form the city and the forces that work upon it. The elements that constitute the city can be separated in permanent and semi-permanent phenomena. In general, public monuments (church, town hall, etc.) are more or less permanent structures while houses and shops are considered semi-permanent elements, since their appearance is highly dependent on fashions in design. In the same way we could view the houses as relatively permanent structures and their facades which are renovated every twenty or thirty years as semi-permanent. The facades and interiors of shops nowadays even change every three to five years.
The image of a city may change as a result of (government) planning and development plans but also through economic factors, restoration or through destruction in wartime. In any of these cases explicit decisions are made concerning the visual appearance. This is what Rossi calls "the problem of the politics of choice" (Rossi 1984).

Studying the history of architecture only makes sense when interpreted from the past to the present. Although we will always view the past with our knowledge of today, we could, to some extent, try to reconstruct past events based on contemporary literature, writings and visual material. The transformation of a city could only be viewed in relation to its past and future. It is not possible to understand the city in autonomous fragments of time, since there are no clean-cut boundaries between two different periods and styles. There will always be a period of transition in which contrasting ideas will overlap. And this is specifically what architectural historians try to examine: the tradition of ideas and their application.

An analysis of the transformation which Paris has undergone over time has recently been carried out by the French group headed by architect-historian Bruno Fortier. His investigation of the development of representational fragments of Paris shows how the city, independent of large-scale planning interventions, organizes itself. In every period the city of Paris would have had a library of ideas at its disposal from which design ideas could be chosen (Fortier 1989). Fortier's detailed graphical description, which revealed the different stages of Paris' urban development, was highly attractive and educational. With his research he demonstrated a method to learn from the past in order to design for the future. Following the research of Fortier the Italian architect Bernardo Secchi studies the structures, patterns and rules of the dynamics of urban processes in Sienna (Secchi 1989). Both Fortier and Secchi approach their subject much as an archeologist would do, studying individual elements and rejecting rigid typological and morphological analyses. In order to demonstrate how the city evolved, not only do they use historical maps, but they also integrate information extracted from these maps in their own designs.

We think, following the historical research of Fortier and Secchi, that a detailed visual description of the architectural achievements of the past could, besides acquiring a better understanding of that past, possibly help us to draw conclusions from it for the future. The difference between their research and our project is, that we will use computer-aided-design techniques in order to decompose and analyse the opaque presence (Porphyrios 1980) of the city and to survey its library of ideas and the choices made in urban management.

The application of CAAD to historical research

The few projects in which CAAD has been used to visualise or analyse historical architecture concentrate on the ideal city, its purpose being in most cases educational (Pelt and Sebohm 1990). There is nothing to be said against studying the conventional images of The Greek City, The Renaissance City or The Baroque City, but the fact remains that cities never exist in that ideal form. A city is always a synthesis of different architectural styles, a collage of different forms which have come down to us through the ages.

Architectural historians who study real architecture work with imperfect, heterogeneous and often incomplete material when studying the transformation of a city. By studying very precisely the subtle transformation over time it is possible to trace the agents and forces that have produced the image of the city. In many cases we have a general knowledge of the
choices made in urban management but the most difficult problem is to detect the real underlying politics of choice. For this, detailed examination is needed. This examination will not gain much by studying the major monuments of our cultural heritage, because the major monuments are permanent elements. They function as landmarks in the city and the city is often recognized solely on the basis of those monuments (Lynch 1960). The real organization of the city, however, has been performed by the more vernacular (semi-permanent) architecture from which we can read the subtle transition in styles and ideas.

The problem of the computability of history with respect to research into real cities has hardly been touched upon, with the possible exception of a study named "Messina 1908, The Invisible City" in which a library of three dimensional elements formed the basis for the reconstruction of a destroyed city (De Cola et al. 1990). The problems involved in the visualization of historical architecture and in using CAAD as an analysing tool seem to be similar to those encountered in the field of design, namely the enormous amount of computer memory required to deal with large numbers of details.

**Researching the changing image of the city: a case study**

This case study describes the first stages of a research project concerning the urban development, the structure of the street pattern and the exterior of the building blocks of Heusden, a small fortified town in the Netherlands. The historical transformation of this town is studied by using three-dimensional computer models in combination with bitmap textures in which all aspects of restoration and renovation as well as urban management can be analysed. The transformation of the architectural object within its urban context will be analysed in a **space-time computer model**.

The town of Heusden was chosen for a case study because its architectural image has changed several times in the twentieth century. Heusden was fortified in the sixteenth and seventeenth centuries by a fortification system modern for its time, and during the Dutch Golden Age (17th century) it was a famous garrison town. Due to economic factors and the leaving of the garrison, the prosperity came to an end in the nineteenth century. In 1904 the old town harbour was filled in and turned into public gardens. At the end of World War II a 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 was built and plans were made to dig out the fortifications and to build blocks of flats on the outskirts of the town. The plans were never realised. Instead of these plans a radical restoration plan was adopted involving repair of the fortifications, reconstruction of the historical street structure and restoration of the old style of building. The town harbour was reexcavated. During this restoration an old map by J. Blaeu (1649) had great influence on the realization of the reconstructed seventeenth-century image of Heusden.

Although the initial idea of the project was to research only the urban development in the twentieth century, it soon became evident that the seventeenth-century map by Blaeu should serve as a reference in order to properly understand the transformation process of the urban morphology.
Methodology

We formulated some starting points for this project. We would use commercial CAD and rendering software for micro computers. As far as the computer models are concerned, the landscape would only be modelled at a very abstract level. Except the water level of the town harbour and the fortifications, the terrain would not be modelled and, as a consequence, all the houses would be modelled on the same level. Since the computer models are research models, photo realistic rendering was not an issue. Rendering would only be used to a limited extent to clarify some ambiguous elements or to make the image a little more realistic. Important factors for this project were the three-dimensional urban structure and information about the facades and the houses. Of less importance were the wall treatment (texture), pavement, vegetation and realistic colouring. Colours would be used either as symbols or to separate functions.

These starting points imply that it is not important HOW an architectural object is being visualized (realistically, idealistically or fictitious) but WHY it is being represented in the computer model. In fact, a well defined argument WHY we choose to pay attention to an object strictly determines HOW the object must be represented. Similarly, the level of detail is strongly dependent on what purpose the computer model will serve. The distance from which the model is to be viewed is a determinant of how detailed the model must be. When one is analyzing a three-dimensional structure of a complete town, details do not have to be displayed. When displaying a small block of houses, details do need to be visualized in the model. Decisions concerning data input are therefore very important and also strictly define the subject to be studied. Further, one has to keep in mind that the desired quality of the results must always justify the time spent obtaining them.

The interpretation of the visual sources is one of the main problems in architectural history. The most reliable information can be drawn from an existing building but in most cases historical buildings have been (partly) destroyed or lost and we then have to rely on drawings and pictures, etc. The problem with historic drawings is that they have not always been carefully carried out, they are often idealizations and differ from the reality as built because changes were made during the building process. Thus, the reliability of drawings and the conventions of depiction used in them have to be carefully analyzed.

Every drawing is an abstraction from reality. Through the ages different conventions of depiction and representation have evolved. A set of traditional visual codes made patterns or types of houses visible in drawings. In the course of time these codes were repeatedly replaced by other codes. In order to detect different patterns the sets of visual codes were all necessary extractions from the real objects (Mitchell 1990). An unavoidable consequence of this process of abstraction is the loss of information (Davis and Hersh 1986). To the architectural historian such loss of information seems to be inexcusable. We, on the contrary, think that the process of abstraction and decomposition can offer knowledge in return about the composition and synthesis of an object (Alkhoven 1989a+b). Abstraction allows us to ignore unnecessary details so that the essential elements of an object become apparent.

The examination of an architectural object requires us to have knowledge about its structure, visual representation and abstraction before we can draw inferences. During the pro-
cess of decomposition decisions can be made about which elements are important for the project and which elements can be left out.

Once a satisfying abstract visual description of every object has been obtained, the transformation over time can be analyzed. After the analysis, new syntheses or combinations with the individual architectural elements can reveal new patterns and types.

The three-dimensional model shows the architectural object in its context. For every time-phase one model will be made. The conventional but most instructive way to show the development over time is juxtaposition of the phases from the same viewpoint. The other possibility is animation by time-sequencing. For the time being we have chosen juxtaposition. The new synthesis shows different combinations of the facades in two-dimensional models.

In connection with this project, several questions can be formulated with respect to the application of CAAD and visualization techniques to architectural historical research. How useful is CAAD in this kind of research and what is the extra information we can extract from computer visualization? How can the method of analysis and new synthesis help us to understand the political choices made in the field of restoration? Could this project have been carried out in the conventional way?

Reconnaissance

Before defining the final planning of the project we decided to carry out experiments on some houses at the Fishmarket in Heusden to study the level of detail and abstraction needed for the project. At the same time we would test the development over time with time-coordinates. With time-coordinates it is possible to show the changing form of a building or town over a certain period of time. Every phase is stored with a time-code while the whole development is stored in the file from Time 1 to End shows an image by image animation of the development of the object. We used a simple surface modeler (Axis) that involved the use of time-coordinates. Cadastral maps 1:1000 were digitized, and the houses with the details (windows, doors) drawn on the planes were stored with the first phase time-code, i.e. the phase 1943. Based on pictures and drawings, etc., we entered the changes made in the following decades in the same file, defining the new time-code for every object. During the twentieth century four different phases of development emerged.

Juxtaposition of the four phases shows that the appearance of nineteenth century elevations had changed by a Dutch seventeenth century style of building with several mullions in the window-frames. In figure 1 it can be seen how the heterogeneous graphical sources can be normalised and integrated into a single computer model. Though only those elements that served the purposes of the project were represented, the model is sufficiently detailed to explain the transformation of the houses. Although we were fairly satisfied with the result, the drawing of all the details on the planes required much time and computer memory and, more importantly, changing the details for every period was not as easy as we thought it would be. Experiments with the latest rendering software in which scanned or painted facades (bitmap-textures) were projected onto the planes turned out to work much better. We therefore abandoned the technique of using time-coordinates and instead we organized the transformation process in layers of time.
Figure 1. Juxtaposition of the four phases of the Fishmarket development. 1943; 1968; 1976 and 1990. Perspective Fishmarket.

Now, the project could be carefully planned in distinct work phases:
1. data acquisition (topological maps, military maps, postcards, drawings, designs, paintings, engravings, texts, etc.)
2. analyzing the conventions and reliability of a certain number of old maps and making a three-dimensional reconstruction of the map by Blaeu (1649).
3. replacing the abstract and idealized picture given by Blaeu by more realistic images.
Figure 2. Scanned map (1649) combined with three-dimensional model (1965).

Figure 3. Scanned map (1649) combined with three-dimensional model (1965).
5. analyzing the choices made in urban management by ordering the visual material in new combinations (new synthesis).

The first step was to collect the visual material to build the computer models. We needed cadastral maps with accurate measurements and drawings from which we could derive the relative dimensions. Further, we needed aerial photographs for the roofs, and any material from which we could derive visual information about the facades and the other elevations. An extensive collection of postcards and photographs produced at the turn of the century provided the basis for that part of the development. In 1943 all the street walls in Heusden were carefully measured and recorded in a complete set of detailed designs which included almost every single house. These designs formed a good basis for tracing the history back to 1900 and plotting developments into the future. From the last thirty years an enormous amount of information was available.

Since the map depicted by Blaeu in the Townbook of the Netherlands (1649) had played an important role in the realization of the recent restoration, the next step was to analyze the map’s conventions of depiction and abstraction. To find out to what extent reliable information could be drawn from this map, we made a two-dimensional computer projection of the outlines of the building blocks and the fortifications of both the map by Blaeu and a recent map. From this projection it became apparent that there was a discrepancy between the two maps which caused a difference of about 15 degrees in the direction of the streets. The old map was also elongated in a downward direction. The streets were depicted too wide and the perspective was probably chosen in order to show the town to its best advantage. By scanning a part of the old map and combining this bitmap image with a three-dimensional model of the town of 1965, it became even clearer how the town plan had been manipulated in the old map, although, in general, the old gates still connect to the modern street pattern (fig. 2 - 3). An explanation for this could be that Blaeu had a contemporary military map of the fortifications at his disposal in which the town plan was drawn in afterwards.

The reconstruction of the map by Blaeu (1649)

When the map by Blaeu was compared with contemporary and later images, the basic forms of the houses seemed to have been represented quite correctly. The facades and the arrangement of the windows and doors, however, were standardized. We investigated these abstract facades which resulted in a typology. It consisted of about 15 types, which had different heights and widths. Following contemporary drawings and prints, it was possible to trace the possible variety of the facades and analyze it in terms of the typology.

First, the computerized map was visualized exactly following the depiction by Blaeu. There were several considerations underlying the decision to visualize the map. Based on the new technology in rendering and the typology we believed it would be relatively easy to make a computer model. The visualization would represent the idealized appearance of Heusden’s Golden Age and would be subjected to further analysis. The second step would be to rescale the computer model and to replace the idealized representation by Blaeu by a more realistic view based on visual and written information about the houses.
Figure 4. The Map by Blaeu from the Townbooks of the Netherlands (1649).

Figure 5. Three-dimensional computer visualization of the map by Blaeu.
Figure 6. The basic model without effects and bitmap textures.

Figure 7. Perspective with effects and bitmap textures switched on.
The old map was digitized and scaled to 1:1000. Since there were almost no contemporary measurements of the houses available, we had to rely on the relative dimensions from the map. Every house in the model consisted of four sides and a roof and two vertical planes for the top-roofs. A bitmap texture of every facade type was painted in Autodesk Animator. By assigning a colour number to a texture map a texture library for the project was setup. Every plane in the model was assigned a colour number which corresponded to the colour number of the texture. The ratio of the texture maps and the plane on which it was projected should match. The rendering software (RenderStar2) linked the textures to the planes in the model. The vertical planes on which the top-roofs were projected were not completely used by the textures of the stepped gables. The unused parts were rendered transparent so that the real stepped gables became visible, even from the other side. Thus, instead of building the facades in three dimensions, a screen of painted facades was put in front of the volumes of the houses. The advantage of this scenographical architecture is that the appearance of the facades can easily be changed by assigning new colour numbers.

At that stage the reconstruction was actually finished. All the houses could be viewed from all sides but the real landmarks of the town (church, castle, townhall, fishmarket and mills) were missing. Without these elements the town seemed dead and for many people unrecognizable. So much so that when the real research-model was finished we decided to do some additional work to make the town look more realistic. Apart from the above mentioned landmarks, we designed the gardens and did some work on the fortifications. Because it was not our intention to create beautiful pictures we only refined the images to an acceptable extent (fig. 4 - 7).

The second step was to rescale part of this model following the cadastral map of 1832 (the first map with precise measurements) and to repaint the facades about which we could find visual information. As for the other houses, we continued our research in literature and we looked for paintings of seventeenth-century houses. Basing ourselves on this visual material, we created three different types of seventeenth-century houses from which bitmap textures were painted. Actually, here one could speak of the replacement of one abstract pattern by another abstract pattern. Then the planes in the model were assigned new colour numbers and the image was rendered. Now the facades could be viewed from close by since the repainted facades were much more detailed. The rigid severeness of Blaeu's map had been replaced by a more dynamic picture (fig. 8).

Three-dimensional descriptive computer model

From both the map by Blaeu and the remodelled map we could derive the old structure of the town and houses. That information was useful for the time-model 1900 - 1990 which we were about to build. We decided not to visualize the period between 1650 and 1900, since the main lay-out of the town hardly changed until 1904 when the town-harbour was filled in. In general, the appearance of the houses had followed the standard Dutch architectural styles. Most of the stepped gables were replaced during the eighteenth century by cornice-facades and the windows were filled in with larger surfaces of glass.

We had to divide the town plan up into eight parts which we would study successively, since the hardware could only handle part of the data at a time. When all the parts will have
been analyzed they will be merged in a single model. We will discuss here the first part that has been finished: the Fishmarket and the town harbour neighbourhood.

The cadastral map of 1900, plans from 1943, 1965 and 1990 showing the outlines of the fortifications and the building blocks as well as the lots were digitized. We started by building the Fishmarket model of 1943, since we had a complete set of information at our disposal. With the data of the exact width and height of the facades and the depth of the lots we could easily build a correct three-dimensional model.

The transformation of every house was investigated and a scheme was designed displaying the image of every house in the researched periods, the dimensions of the facade and its colour number. This scheme was used as a reference while building the model and connecting the textures. The method we used was the same as the visualization of the old map. Instead of using the typology, the more probable image of the facades of every single house on the Fishmarket (as recorded in the scheme) was painted in Autodesk Animator. These bitmap textures were connected to the planes in the model. After the 1943 phase the other layers of time were modelled in the same way. Viewing the phases one after the other, a kind of animation showed the whole transformation over time (fig. 9 - 11).

This descriptive model provides information about the plan, the three-dimensional structure of the houses and about the appearance of the facades in different periods. One can see how the Fishmarket area has developed over time by examining the models from the same viewpoint. However educational the models might be, the static viewpoint of a three-dimensional model does not allow us to get a clear picture of the development of every house at the same time. Further, the three-dimensional descriptive model does not explain how and why the houses were changed, which houses were reconstructed or what the dynamics of urban management had been.

New syntheses

In order to solve this problem we needed to build new models in which the individual architectural elements were detached from their context. Using the bitmap textures, we were able to create several combinations with them: houses or facades of the 17th, 18th, 19th and 20th centuries; buildings of historical importance; the restored buildings in chronological order (1965 - 1990) and buildings restored by architects. We had chosen these combinations because we thought that each of these combinations would reveal to us aspects of the choices made by the local government or by architects involved about how the town should look like.

Although only a small part of the town had been involved so far, some conclusions could be drawn from these two-dimensional models. The period 1900 - 1943 shows mostly ad-hoc interventions. Some houses were built in contemporary style (Jugendstil) between 1905 - 1915. Many shops were renovated with display windows. After World War II the houses that were destroyed during the war were in most cases rebuilt the way they were.
Figure 8. Heusden’s Fishmarket as it might have looked like in the seventeenth century.

Figure 9. Three-dimensional model showing the Fishmarket in 1900.
Figure 10. Three-dimensional model showing the Fishmarket in 1943.

Figure 11. Three-dimensional model showing the Fishmarket in 1990.
The real changes in the image of the town started with the 1965 Development Plan on the basis of which almost every single house in Heusden was renovated or reconstructed. The Development Plan itself was based on the spatial structure as can be seen on the map by Blaeu. In general, the spatial structure of the houses did not change much, since the old structure was still intact. The transformation of the image of the city can best be seen in the treatment of the facades.

Most attention seemed to be given to houses that originated in the seventeenth century and the houses that were assigned as public monuments. It is striking that almost without exception these houses were reconstructed in a Dutch seventeenth century style, though not all the stepped gables were rebuilt. Some seventeenth century houses from which the facades were renovated in the eighteenth or nineteenth centuries, were now reconstructed in a Dutch seventeenth-century style with mullions in the window frames. There is another example which confirms a preference for the image of seventeenth-century (or begin eighteenth-century) architecture. In the windows of a mid-nineteenth century mansion mullions divided the window into thirty-five lights, as would have been done in the late seventeenth century or in the beginning of the eighteenth century. The building looks even older than it originally was (fig.12 - 13).

Buildings from the beginning of this century (Jugendstil) were in most cases demolished and replaced by types or abstractions of buildings that existed at the same place before. The houses that were not reconstructed in seventeenth-century style, were mostly restored following the image of the 1900 postcards. The new synthesis of the restored buildings in chronological order demonstrate that buildings were more radically reconstructed in the beginning of the restoration (probably because there was more money available for restoration work) than in the later period. The architects involved had also great influence on the transformation of the facades. Some architects had chosen to reconstruct the seventeenth-century (or begin eighteenth-century) image or to use the 1900 postcards as their guides, others maintained the main appearance of the facades while using modern elements in addition.

The above described project has not yet been concluded. In the near future, the other parts of the town will be visualized in order to analyze their transformation over time. Some of the formulated questions can only be properly answered after the whole town has been visualized and analyzed.

Now that we are at the end of the description of this pilot project we must answer the question if this project could have been carried out in the conventional way. The models displaying the new synthesis are very simple and could have been drawn by hand, but it would have taken very long (we analyzed about twenty models!). In spite of the fact that it might indeed be possible to do this in the traditional way, we think that computer models are much more flexible to manipulate the data which can easily be changed or put in a different order. In this way every possibility and combination can be explored. From the new synthesis direct visual proof can be derived about how the town has changed. From the educational point of view the models displaying the new synthesis do not look very attractive. We therefore think that there should be two different ways of using the computer models: one in which only the essential elements are displayed which serve the research-project (new synthesis) and one which is rendered more realistically for showing to the public (three-dimensional model).
Conclusions

The application of CAAD and visualization techniques to architectural historical research provides a method to analyze the transformation of historical architecture and the dynamics of urban management. Although this project could have been carried out in the conventional way, i.e. with or without making drawings by hand, computer visualization seems very useful in normalizing heterogeneous graphic material. The process of extracting information from the opaque presence of the architectural sources produces detailed knowledge of the object under study. A computer visualization demonstrates direct visual feedback and proof of the analysis. Further, the reconstruction of the seventeenth-century map appeared very useful in analyzing some cartographic conventions and typologies which so far had been obscure. From the above described project one can conclude that the results are highly dependent on detailed delimitation of the boundaries of a project and on argumentation regarding the choices for every step taken. The combination of three-dimensional models and texture maps opens the possibility to manipulate relatively detailed architectural objects in a flexible way. They also enable us to apply two levels of abstraction. A three-dimensional model, which is visually very attractive and instructive, describes the architectural object in its context. The new synthesis, however, serves as research model displaying the isolated architectural objects in different combinations. This makes the synthesis very flexible but less educational. Although the educational value of abstract hidden-line images might be sufficient to support the research project, more realistically rendered images seem to heighten the sense of the town coming alive.

![Figure 12. Buildings of historical importance. 1900; 1943 and 1990.](image)
Figure 13. Some buildings restored by the architect Peetoom.

Technical Notes:
Hardware: 33Mhz. 386/387, 10 Mb., 1024x768 in 256 colours. Software: Axis, RenderStar2, AutoCad (release 10), Autodesk Animator. The final pictures were calculated at the resolution of 4096x2732 and processed by a digital slide recorder.

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References


