Reflections on the digital reconstruction of the portico and garden pavilion of the Rubens House

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Abstract

This article presents a digital, geometrical analysis of the relative positioning of the *portico* and *garden pavilion* of the *Rubens house* in Antwerp (Belgium) in regard to the main entrance of the house. While this is not a fully accurate historical reconstruction, the creation of a three-dimensional model allowed assessing certain geometrical properties of the site and how they can be related back to the depiction of the architecture into the iconography of Rubens.

Based on a combination of available blueprints from fairly recent site measurements and photographic imagery taken on site, we were able to derive a reasonably accurate 3D reconstruction in a limited timeframe, sufficient for 2D and 3D visualization and a geometrical analysis of the optical effects that are apparent in the site.

In addition, the article reflects on the applied software-based methodology, including the benefits and pitfalls of *Building Information Modeling* (BIM), which is increasingly being used for the modeling and management of digital building models worldwide, but is not oriented towards historical models. However, the use of BIM allowed maintaining a consistent link between 2D and 3D graphics, which is not available with other CAD-based 3D modeling or 2D drafting techniques.

Introduction and context

Rubens house in Antwerp, built in 1611-18, was his own residence and he was deeply involved in the concepts and realization. Throughout the centuries, a large part of the site has been modified and eventually rebuilt, leaving only the Portico and the Garden Pavilion as reasonably "original" or authentic parts of the house and the connecting garden. Figure 1 displays the Rubens house as it exists today, including the portico, through which the garden pavilion can be noticed.

Fig. 1. Rubens House (left), Portico and Pavilion (right) (Photo by the author)

As described by Lombaerde (2002) there is an apparent optical line that can be drawn from the entrance of the house on the *Wapper* street through the middle arc of the portico towards the top façade of the garden pavilion. An initial rough model was made to verify this assumption and this formed the initial hypothesis to be further elaborated in a more extensive model of not only the portico and pavilion but also the garden and the main house. This elaboration is the subject of this article.

The use of 3D modeling software for Digital Cultural Heritage purposes has been described in general by Alkhoven (1999) and the techniques described have become common place for historical 3D reconstruction and visualization. Vandevyvere et al. (2005) describe a reconstruction framework and methodology that is meant to assist the interpretation process. All possible resources and documents are organized into a resource table, the so-called "*meta-file*", to collect not only the references but also meta-information about accuracy, known facts and a relation with the project. They describe how 3D visualization techniques can be utilized beyond pure photorealistic visualization to represent aspects of the project. E.g. color-coded images are used to indicate levels of certainty within the reconstructed model.

Boeykens (2011) further discusses not only the use of 3D visualization techniques such as rendering and animation, but also the potential of real-time environments using gaming technology, to insert interactivity into the 3D model and to allow the visitor to walk around a site in real-time, as if they were inside a computer game.

The Building Information Modeling Methodology

The reconstruction is an application of the *Building Information Modeling* (BIM) methodology in an historical context. BIM is an approach that uses digital building models to support the construction process. In BIM, a building is

created as a virtual model, in three dimensions, using specialized software that not only captures the 3D geometry, but also the information that is required for the interpretation and construction of the building. In contrast with traditional *Computer-Aided Design* (CAD) systems, the main entities in BIM are not generic, geometric objects, such as lines or volumes, but parametric entities that represent actual building elements, such as walls, floors, doors and roofs. Each object has different possible representations and carries along not only information about the object itself, such as material quantities or dimensions, but also the relations between elements.

The application of this methodology is rising worldwide, with a strong rise in countries such as Norway, Finland, the Netherlands and the United States. The use of BIM is reshaping the construction industry as it allows partners in building projects to improve their collaboration and communication through the exchange of models instead of documents ("drawings"). The main drivers for BIM adoption are increased productivity, lowering of failure costs and improved communication between partners.

In the rest of this article we assume the reader to understand some basic premises of the usage of BIM in the context of building modeling. No other familiarity is required otherwise:

- The full building is modeled as a series of parametric objects;
- Different representations are used to visualize these objects, including 2D drawings, 3D Perspective and axonometric views, sections and elevations, but also listings of text-based information for analysis purposes;
- Moreover, the same model can be filtered in different ways to allow for a wide variety in the information that is displayed in these representations;
- All possible documents relate to the same model, indicating a forced consistency between drawings, schemes and visualizations.

The applied BIM software in this study is *Graphisoft ArchiCAD*, accompanied by *Trimble SketchUp* for 3D reconstruction from photographs and *Maxon Cinema4D* for photorealistic rendering and animation.

The application of BIM for historical reconstruction is not new, but not common either. Martens and Peter (2012) collected a wide variety of 3D models of Jewish synagogues in Vienna (Austria) and have developed a structured modeling approach throughout the series of reconstructions. While they did apply the same BIM software as was used here for the Rubens house, the focus thus far has been mostly on the level of generating usable 2D documents (plans, sections and elevations) and 3D visualization (renderings). Boeykens et al (2012) discuss the combination of the structured modeling approach from Martens and Peter with the metafile methodology as described earlier by Vandevyvere. While the potential of parametric modeling as made available by BIM applications is also mentioned, it is thus far not fully applied.

It has to be noted that commercial BIM software is strongly focused on current design praxis and as such does not provide much library content or dedicated modeling support for historical projects. However, recent additions to the used software that became available in the course of the project have provided hugely improved modeling functionality for freeform geometry, albeit mostly based on planar surfaces. This is a trend with many CAD and BIM systems, which inherit some of the modeling toolset that made the *SketchUp* software so widely popular

with architects and designers, as it allows a less constrained approach that still supports accurate modeling.

The user of the BIM software can create custom objects more easily, but mostly as static geometry. To inhibit parametric behavior, additional scripting is required, which only makes sense when objects will be reused in other projects. As such, a large part of the model is created as unique geometric objects, suitable for this specific project.

In addition, the possibility of inserting images, photographs and even PDF documents as underlays during modeling was an important aid for the reconstruction process, once all references were properly scaled.

Other authors mention the increased integration of surveying techniques, such as Laser scanning and Photogrammetry into a BIM methodology. Arayici and Tah (2007) specifically describe a case study where point clouds, resulting from the laser scanning process, are being integrated into a BIM model. Murphy et al (2009) also mention the importance of point clouds for historical reconstruction to be integrated into a BIM process.

Elaboration of the 3D Reconstruction

The reconstruction is carried out in different models, which are assembled for the analysis schemes. At any time, changes in the models are reflected in the assembly model, which allows further refinement throughout the reconstruction process.

The Portico

The first section that was reconstructed involved the portico. A series of scans of blueprints from the City of Antwerp were available to be used as reference drawings for the reconstruction. While the overall dimensions are respected as much as possible, it was decided that for the purpose of the analysis, some simplification was justified. The statues and other sculptures were replaced with extruded silhouette profiles, as they are not influencing the analysis. In addition, some irregularities of the actual built portico were straightened and assumed to be largely symmetrical as to diminish the modeling efforts. While this is not acceptable for a restoration context where accurate preservation is intended, this was acceptable for the geometrical analysis in this study.

The portico as modeled is depicted in Fig. 2, which shows a perspective view from within the cortile, but elevated above eye height.

Fig. 2. Portico model

While the available blueprints were reasonably detailed, it was found that there were several inconsistencies between some of the sections and the plan drawings, which are often unavoidable in 2D drafting. Simple overlaying the available drawings already displayed differences that had to be interpreted to form a consistent 3D model.

In addition, much of the sculptural detail was deliberately omitted, to avoid extremely long and cumbersome modeling efforts, which would also stress the software and available hardware to make the model unmanageable. The main statues have been included as extruded outline models, starting from the silhouette as visible in the elevation drawings.

Garden Pavilion

Two hand-drawn documents were used to reconstruct the majority of the pavilion layout, which was made symmetrical as much as possible, where relevant. However, the positioning of the middle statue at the back wall was clearly offset from the symmetry axis, which will be further discussed for the analysis in the next section.

The model is quite detailed, although the statues are simplified, as visible in Fig. 3. The baluster and the front arch and columns indicate a symmetrical concept, although the actual pavilion has some noticeable asymmetrical elements.

Fig. 3. Garden Pavilion model (left) and current situation (right) (Photo by the author)

Garden

While a scaled garden layout drawing was also available, it proved to be not so representative for the actual state of the garden, so it was mainly used to provide the overall dimensions of the site and to assist the assembly.

Fig. 4. Garden Model

All plants and garden accessories have been simplified, to not place too much burden on the modeling system, while still allowing convincing visualizations. The main point-of-interest is the garden path connecting the portico with the garden pavilion. It is seemingly perpendicular to the portico and forms the main dividing axis, although the garden is only partially symmetrical.

The Rubens House

The main house, which has been completely rebuilt throughout the ages, was not the main focus of the reconstruction. It is included to place the other models in a more complete context and to include the main entrance passage, which is assumed to be the primary point-of-view for which the sequence entrance-cortile-portico-garden-pavilion has been envisaged. The model contains the frontal façade, with the main openings and arched entrance passage and the overall shape of the roofs and roof vaults.

Fig. 5. Rubens House Model

The position of the windows and entry arch is fairly precise, whereas the roof and its extensions are an approximation. The neighboring houses are indicated as grey volumes with an overall faithful roof shape.

Overall site and context

It has to be noted that in the scope of the project there was no room for full site measurements, as the analysis did not require it. So a deliberate choice to work from available resources was deemed a feasible alternative.

While there was also an effort to integrate available aerial photography and maps of the larger area, they were inconsistent and lacked the required detail to assist the reconstruction of the site, so they were mainly used to fill in some of the gaps that were not available from the other resources, such as roof shapes or slopes.

Fig. 6. Aerial Image of the site (Bing, Microsoft)

An existing Google Earth model of the whole site¹ was imported as well, but showed widely differing roof heights and was mostly disregarded in the final model. It has been used while modeling to place the other buildings in context.

Fig. 7. Rubens house Site model (SketchUp model by Nick Oberg, as user "SittingDuck")

Analysis

The reconstruction is divided in a few separate models, which have to be assembled to create the overall site model. This allowed the reconstruction of multiple possible interpretations of the site.

- The first assembly restores as much as possible *the actual situation*, which is mostly assessed and compared from the garden plan and the aerial imagery.
- The second assembly is a *theoretical ideal situation* where the entrance arch of the house, the central axis of the portico, the garden path and the garden pavilion are all assumed to be oriented identically around a central symmetry

¹ <http://sketchup.google.com/3dwarehouse/details?mid=1a354a50ad35179948905349b0d69f29>

axis. This is clearly not a faithful reconstruction, but rather how the ideal concept of the whole site could be interpreted, e.g. how it “could have been”, in the mind of the painter-architect Rubens.

- The final assembly is based on *situation in paintings and drawings*. It requires a distorted positioning of the different elements on the site, to more closely resemble the sequence of portico and pavilion as depicted in some of the paintings that refer to this site.

The actual assembly of the parts of the site can be seen in Fig. 8. It shows the different parts of the site when joined in a single overview model. The adjoining buildings are represented as basic volumes.

Fig. 8. Assembly from different sections

We are in particular interested in the geometrical ratio between the heights of the middle arc of the portico and the top of the garden pavilion, in comparison with their mutual position. As mentioned by Lombaerde (2002), these ratios are apparently derived from a central viewer position, located closely to the entrance arch of the Rubens house.

Fig. 9 shows a sequence of vistas that occur when the visitor steps through the arched passage door onto the cortile, where the pavilion appears inside the middle arch of the portico.

Fig. 9. Sequence of views from street to portico (Photo's by the author)

Within the assembly model, we can display this sequence as a cutout from the model. We use the theoretical, ideal assembly, where the house, portico and pavilion are all aligned perpendicularly, which is not the case on the actual site.

Fig. 10. Cutout of the assembly, along the garden path

By shifting the whole line-of-sight upward, to be placed more or less on eye-height, we can indicate this line visually on top of the site assembly and derive the ratios a/c and d/e (with $c = a + b$) as depicted in Fig. 11 and Fig. 12.

Fig. 11. Line of sight through section

Fig. 12. Ratios between cortile/portico and garden/pavilion

Both ratios, when measured on the model, resolve to 0,35 and are (almost identical). This is very close to the ideal ratio: $a/c = d/e = 1/3$

While the theoretical, ideal assembly would place all elements on a single, symmetry axis, this requires shifting of the statues and the roof elements of the pavilion towards this axis, which is clearly a distortion of the actual position of these elements. The difference between the actual and the idealized situation is clearly visible in the pavilion, as shown in Fig. 13.

Fig. 13. Difference between actual (left) and ideal (right) model of the pavilion

The movement of the statue in the pavilion is an indication of how the actual perspective is shifted to compensate for these differences and to still provide a seemingly symmetrical line-of-sight in the actual situation.

Several historical resources depict the ensemble of the portico and pavilion. Where they allow the viewer to have an impression of the ambience of the site, it is by no means accurate or faithful to the actual dimensions. They are however interesting as they helped with the restoration. Drawings by Jacob Harrewijn are seen as the oldest relevant depictions of the Rubens house and the relation between the house, portico and garden. To approximate the positioning of the viewer from these drawings, we have to manipulate the position of the garden pavilion and the portico, to arrive to a similar viewpoint.

Fig. 14. Jacob Harrewijn drawing (1684)

This drawing gives the impression that the whole courtyard is wide and open, where in reality it is much more enclosed. To reconstruct a view that resembles this image, we need to remove the Rubens house and position the viewer further away and at an elevation. It also requires a wider view angle to have a similar perspective (about 90°).

Fig. 15. Viewpoint resembling the Harrewijn 1684 drawing

Another Harrewijn drawing, from 1692, removes the portico and shortens the cortile and also the distance between house and garden pavilion. It suggests a perpendicular positioning of the different parts, which is in line with the main concept of the site.

Fig. 16. Jacob Harrewijn drawing (1692)

This last situation is impossible to recreate from the current model, due to the many differences with the actual site. It can be approximated with non-uniform scaling of the different parts of the model. As an alternative, we stretched the height of Fig. 17 almost 50% to get a ratio more akin to the drawing.

Fig. 17. Non-uniformly stretched image from 3D assembly model

While these drawings have no dimensional value for the 3D reconstruction, they do present an insight into the conceptualization of the site.

Conclusions and reflection

3D reconstruction of historical buildings and sites is not a new development. Advanced visualization has played a pivotal role in making the reconstruction results accessible to a wide audience, especially when applied with animation and real-time techniques. While traditional CAD systems allow for quite accurate modeling and drafting of historical sites, this article explained some of the benefits of the application of BIM in historical reconstruction and also some of the aspects in which BIM software and libraries need to be improved.

The interpretation of different possible variations of the Rubens house site is only possible through the use of 3D modeling techniques. Precisely through the usage of a BIM environment with sufficient support for complex geometry, displaying different alternative versions and model linking for the assembly, the same model could be presented in different layouts, without the need for several disconnected models.

The trend towards the usage of BIM for architectural design and construction cannot be denied anymore. Future reconstructions will more and more benefit from better-structured approaches and the added levels of information the BIM provides. To assist this evolution, future work will focus more on the elaboration of an optimized object library for reconstruction work. Parametric building objects that can be applied in a variety of reconstruction projects not only assist the modeling efforts, but also the collection and extraction of information from the model.

The increased power of software and hardware, further help improving the possible amount of reconstruction detail. However, static geometric modeling is always created at a fixed level of detail. The model creator deliberately has to decide to which level of detail the model needs to be elaborated. The use of parametric objects will further facilitate the automatic generation of lower and higher detailed models from the same master BIM model.

Whereas the Rubens house model is sufficient for the intended purposes, the next step could be a more complete reconstruction of other buildings on this site. In addition, the modeled environment can be used to allow a true real-time representation, e.g. for online viewing and dissemination. The usage of these techniques has already been proven valuable in other reconstruction cases, e.g. using gaming technology on tablets or smartphones or via the web browser.

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Bibliography

- Alkhoven, Patricia, 'The Reconstruction of the Past: The Application of New Techniques for Visualization and Research in Architectural History', in *CAAD Futures*, 1991, pp. 549–566
- Arayici, Y, and J Tah, 'Towards Building Information Modelling for Existing Structures', *Structural Survey*, 26 (2007), 210–222
- Boeykens, Stefan, 'Using 3D Design Software, BIM and Game Engines for Architectural Historical Reconstruction', in *Designing Together - Proceedings of the 14th international conference on Computer Aided Architectural Design Futures*, ed. by Pierre Leclercq, Ann Heylighen and Geneviève Martin (Liège (Belgium): Université de Liège Press, 2011), pp. 493–509
- Boeykens, Stefan, Caroline Himpe, and Bob Martens, 'A Case Study of Using BIM in Historical Reconstruction - The Vinohrady Synagogue in Prague', in *Physical Digitality - Digital Physicality. 30th eCAADe Conference Proceedings*, ed. by Henri Achten, Jiri Pavlicek, Jaroslav Hulin and Dana Matejovska (Prague

(Czech Republic): eCAADe and CVUT, Faculty of Architecture, 2012), i, 729–738

Lombaerde, Piet, 'The Distribution and Reception of Rubens's Palazzi Di Genova in the Southern Netherlands: a Status Questionis', in *Architectura Moderna 1: The reception of P.P. Rubens's Palazzi di Genova During the 17th Century in Europe: Questions and Problems*, ed. by Piet Lombaerde (Turnhout: Brepols, 2002), pp. 99–120

Martens, Bob, and Herbert Peter, 'A Long-term Scope of Actions for Reconstructed Cultural Heritage : Maintaining a Virtual Archive of Non-Existing Synagogues', *International Journal of Architectural Computing*, 09 (2012), 285–302 <doi:10.1260/1478-0771.9.3.285>

Murphy, Maurice, Eugene McGovern, and Sara Pavia, 'Historic Building Information Modelling (HBIM)', *Structural Survey*, 27 (2009), 311–327 <doi:10.1108/02630800910985108>

Vandevyvere, Han, Herman Neuckermans, and Krista De Jonge, 'Digital Historical Reconstruction : Case Studies of an Interdisciplinary Task', in *Augmented Heritage, proceedings of EurolA 10* (Damascus (Syria), 2005), pp. 79–93