IFC based BIM or parametric design?

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Abstract

This paper discusses examples of non-standard and interactive architecture. It further focuses on the software that can be used to develop architecture in these new complex paradigms. This complexity asks for collaborative design, also over the Internet. IFC based BIM is currently the most used method for data exchange, but is of no use with parametric design software. An example clarifies this. The discussion is: do we drop parametric design or do we drop IFC. To answer this question we should dive deep into parametric design and find the advantages that would be lost.

*Keywords*: BIM, IFC, parametric design, non-standard and interactive architecture

1 Introduction

Non-standard architecture (Figure 1), officially introduced at the exhibition with that name in 2003 at the Centre Pompidou in Paris (Oosterhuis, 2003), is architecture using complex geometry based on nurbs, lofts, booleans etc. and not simple Euclidian forms like cubes and spheres. File-to-factory, also known as Computer Numerical Controlled (CNC) fabrication makes this affordable.

On top of this our group Hyperbody, directed by Prof. Ir. Kas Oosterhuis, develops a new paradigm called interactive architecture. This is architecture that reacts on changing circumstances, but also proactively changes and communicates with its users and environment.

An example in practice of interactive architecture is the Kunsthaus in Graz, Austria of Spacelab (Bix, 2009). The façade is able to display animations and movies, but also interactive video experiments are possible.
In order to discover new possibilities of interaction our group experiments with interactive installations. We developed several muscle projects (Figure 3). The most recent installation is called Interactive Wall and consists of 7 interactive moving fins with 96 LEDs each, which also interactively change patterns and sound (Figure 4).

Both non-standard and interactive architecture need specific software solutions. We developed applications based on swarming with Virtools. The idea is that a point cloud should develop into architecture and urban layout, by simple swarming rules, as found in flocks of birds (Figure 5 left side by Tomasz Jaskiewicz). Advanced design tools were developed using Voronoi and Delaunay triangulation (Figure 5 right side by Christian Friedrich). We also developed an application for collaborative design over the Internet using the database server of Virtools (Hubers 2008). After a global layout of the design using these tools we need CAD software to work out the design in more detail. However because of the complexity of non-standard and interactive architecture and the many disciplines that need to work together it is important that the design can be adapted very quickly. Parametric design software makes this possible.
2 Parametric design software and BIM

Parametric design software is CAD software where properties of objects are defined by variables. E.g. instead of defining the height of a column to be 3m it is defined by the variable ‘StoreyHeight minus the variable ‘FloorHeight’. Those variables can be used for many other objects too.

There are several types of parametric design software (Hubers 2008). We worked with Generative Components (Figure 6), which is based on Microstation and Digital Project, which is based on Catia (Figure 7 and following). The advantage of parametric software is that if the virtual 3D model is set-up appropriately, changes in the parameters generate within minutes complete correct models and consequent bills of quantities and 2D sections. This makes it possible to adjust the design until the last minute.

Figure 6. Unfolded double curved surface in Generative Components.
Collaboration with other stakeholders becomes affordable in this way. These systems have also good possibilities to unfold the geometry in such a way that the data can be send to computer numerical controlled machines in the factories.

One drawback is however that data exchange with partners that don’t use the same parameters and algorithms becomes a ‘one way street’. 3D Building Information Models (BIM) are becoming the standard for data exchange in the building industry. The International Standard Organization developed the Standard for the Exchange of Product model data (ISO/STEP). The International Alliance for Interoperability -now called buildingSMART (IAI, 2009)- derived from ISO/STEP the Industry Foundation Classes (IFC). BIM based on IFC is now much discussed. But it is not compatible with parametric design software because it is describing objects and attributes, while the parametric design software needs parameters and algorithms. This becomes an important issue because the first signs that others than architects are going to use parametric software are there (Breider and Coenders, 2009). It will completely change the approach of collaborative design. The next quote of a fictive story about the exchange of information between an architect and a structural advisor (not yet using parametric software) illustrates this.

“The data are sent again to the advisors in a new version of the BIM. The structural advisor calculates that the columns are too thin now and that the diameter should be 300mm. Again the architect doesn’t need the updated geometry. He reruns his script with this value and generates the final model in Figure 7.”

![Figure 7. Parametric changes in a 3D model.](image)

The consequence of this would be to drop IFC based BIM or to drop parametric design software. Before we do the last, we should have a close look at the advantages of this software.

In discussions with an architecture office we found that there was a need for adaptable panels in the skin of non-standard buildings. The dimensions of the skin vary often during the design; e.g. because the needed floor surface changes or a new fabrication method is found for the panels etc. It appears to be much work to adapt every time the panels to the new skin. Digital Project has the solution of Powercopy for this. A Powercopy is a parametric part that you can store somewhere on the hard disk and then apply in your design at any place where the input parameters of the Powercopy occur.

We applied this method for the panel. As input parameters we used 4 crossing lines on a skin surface. To make it more interesting we also made a parameter that determines if the panel is curved like a cushion or flat. But that is incorporated in the Powercopy with a default value, so one can change this afterwards.

The next thing is to find a way for automatically generating the grid of crossing lines on the skin surface (Figure 8). It should be done in such a way that when the surface changes, the grid changes too; but with constraints. The horizontal and vertical distance between the lines in the grid should be between a maximum and a minimum value that can be set as parameters (in the object tree at the left), because these dimensions are bound to the machine in the factory or the calculations of the construction. For this a VBA script can be used that puts the result in a section that can easily be deleted if another generation of panels is needed. The script to make this involves some modular arithmetic. The details of this would go too far for a paper like this.
The last thing is to find a way for automatically placing the Powercopy on the grid on the skin surface (Figure 9). This can be done with a VBA script too, through the InstanceFactory, but for the research we used the method of Knowledge Pattern. This is using a native scripting language based on C++/Java. The script uses the resulting splines from the script above and loops through all the crossings to apply the Powercopy. However there is an error in the script. That is why not all panels are rendered in Figure 9. Knowledge Pattern doesn’t have a helpful debugging possibility.

3 Discussion

In the meanwhile our group decided to work with Rhino and this research with Digital Project was stopped. The reasons are rather pragmatic. Most of our educating staff is interested in Rhino and doesn’t know how to work with Digital Project. They also find it too complex to learn. The fact is that Digital Project is very powerful and has many tools, but that is at the same time its disadvantage: one has to be trained and keep in shape to be able to handle it efficiently.

Rhino is not parametric, but with the Grasshopper plug-in it can be used in that way. It has the possibility of VB script (which unfortunately is not the same as VBA). It would be interesting to see if the scripts of Digital Project could be converted. Of course the objects and their methods, attributes etc. have different names. If we succeed in writing a translating application, it could demonstrate a way of advanced data exchange between parametric software applications. It could be that we also start working with Autodesk Revit, because some of our partners start using it.

An interesting research would be to find in which way the cooperation with advisors could work using parametric software. Probably it would be wise to first try that with the same software and not to loose time with translating scripts. Breider and Coenders (2009) are using Generative Components. In my opinion this research should have the highest priority.
A drawback of parametric design software is that very precise knowledge is needed of how the models are build-up, what parameters are influencing what parts of the models and where did the maker of the model violate the principle and added quickly something by hand. This is a problem if one didn’t work for some time on a model or if the model was made by somebody else. In fact the designer becomes a programmer. Many designers don’t like that. At the other hand the parametric programs are complete CAD programs and can deliver bills of quantities, 2D sections with all annotations needed for permissions, unfold geometry into parts and generate files with these parts that can be sent to CNC-machines etc.

Already in this paper we mentioned 5 different parametric software applications and there are many others. They all have their own names for objects, methods, attributes, functions etc. and exchange of parameters and algorithms between them (the most important exchange needed) is therefore problematic. Maybe it would be good if an ISO standard would be developed for this? Because the advantages of parametric CAD can be so important that architects and advisors start using this software even if IFC based BIM is not possible.

References


