

Muqarnas in Blender: Modelling and Rendering

Stephanie Schuldes
schuldes@cl.uni-heidelberg.de

Laboratory WS 2004/05
supervised by Michael Winckler,
Interdisciplinary Centre for
Scientific Computing,
University of Heidelberg

16th March 2005

Contents

1	Introduction	3
2	Basic Elements	3
2.1	Basic Side View	3
2.2	Cells	4
2.3	Intermediates	5
3	Materials and Textures	7
4	Example Muqarnas	8
5	Blender Evaluation	8
A	Appendix	11

1 Introduction

Blender is an open source 3D design and rendering tool which allows to create high quality graphics and animations. It is widely used both by professionals and amateurs. At the IWR, the Visualisation Group wanted to find out if Blender was also suited for one of their research topics, the reconstruction and visualisation of Islamic stalactite vaults (also called "muqarnas"). From these thoughts the idea of a laboratory emerged.

This report wants to present the results from the laboratory, whose aims were twofold: First, knowledge about Blender should be acquired: Is the program suited for our task? Is it easy to use?

Second, presentable results were desired, i. e. 3D models of all six basic forms (cells and intermediates) and one or two small example vaults.

2 Basic Elements

2.1 Basic Side View

According to al-Kashi's rules, I first constructed the side view used for the 3D elements. For this I added a plane and created a Bezier curve to fit the descriptions. Then I converted the curve to a mesh in order to intersect it with the plane, obtaining the basic side view.

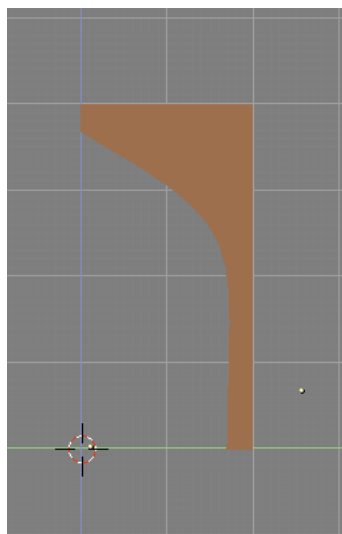


Figure 1: Basic Side View

2.2 Cells

Some of the cells were constructed only with help of the grid in Blender, but for others (and especially for the intermediates) it seemed to be better to use an image of the top projection as background in the Blender window. The image can be scaled to fit the proportions of the side view and is a very helpful guide. Note that (at least in my experiments) a background image can only be loaded in a new Blender file.

The construction mainly took place in the top view window, but splitting the screen and setting the other windows to different perspectives is useful for control and finetuning of the final shape.

Square

For the square element, I aligned two side views in right angle, extruded both of them (Edit Mode, top view), and joined the meshes.

Rhombus

I placed two side views in top view (angle 135°) and extruded both of them. After each extrude step, I dragged the still marked side (indicated by marked vertices) to fit the rhombus ground view. Having done this with both side views, I joined the meshes (Object Mode).

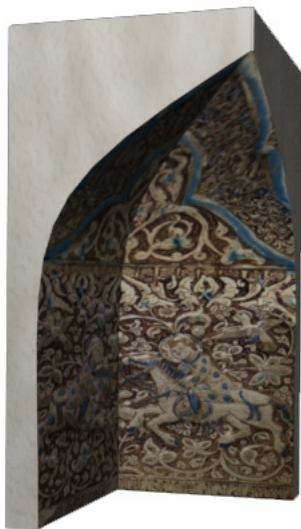


Figure 2: Square Element

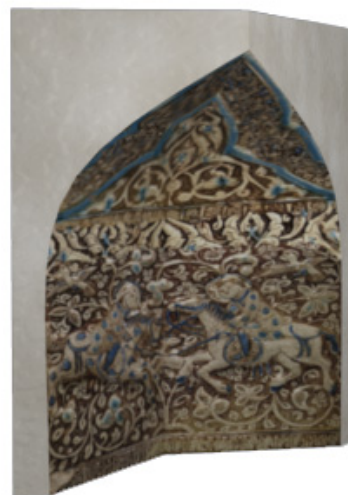


Figure 3: Rhombus Element

Jug

In contrast to the cells mentioned above, jug and almond can be constructed in a different way: not by extrusion but by spinning. In a new file with one side view object, I changed into Edit Mode and selected all vertices (AKEY). The rotation can be configured in the Mesh Tools Menu (in Edit Panel). I set spin steps to 1 and degree to 45. Then I placed the 3D cursor at the end of the basic side view (top view window), since it marks the rotation point. All that remains to do is click the "spin" button, then the top view window, and repeat once to receive a quarter octagon.

Almond

The almond element is constructed in basically the same way as the jug, I only set the spin steps to 2 this time.

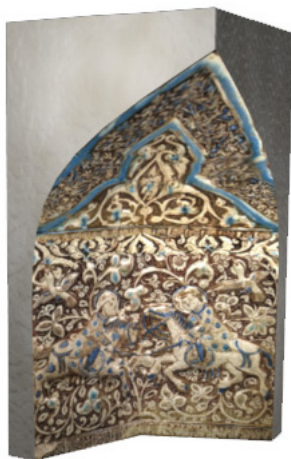


Figure 4: Jug Element



Figure 5: Almond Element

2.3 Intermediates

Large Bipod

For the bipeds, I also used the spinning method, but with some additional editing. The spinning step resembles the description of jug and almond construction (settings: spin steps 2, degree 90). Then in the top view window choose "Vertex Loop" from the Select pulldown menu and mark the middle line of the figure. I scaled this part on the X axis (SKEY, XKEY), which in the end becomes the curved inner edge of the element. For exact scaling I recommend the background image technique mentioned above.

Small Biped

Again, the small biped is very similar to the large one, the only difference being a spin degree of 45.



Figure 6: Large Biped



Figure 7: Small Biped

Other Intermediate Elements

In the course of composing the example muqarnas, I came across two intermediates which I had not modeled yet, but they were rather easy to construct.



Figure 8: Fill 1



Figure 9: Fill 2

For the first one, I rotated the basic side view by 45°. In Edit Mode, I selected all vertices (AKEY) and extruded (option: region) with CTRL pressed by two grid

units. Finally, I rotated the still selected vertices by 45° and dragged them to fit together with the rest of the mesh (top view should be a right triangle). The point where the two (former) basic side views meet has to be the end where the element is open.

The second "new" intermediate element resembles the small biped, but it has no inner edge. Its construction is similar to the one just described. This time, however, I simply extruded the basic side view (without rotating it in advance), and rotated the still selected vertices by 45°. In contrast to the first element, it is the back ends of the basic side view which are supposed to meet now, so that the element gets a pedestal like the bipeds.

3 Materials and Textures

In order to obtain a realistic modelling of a muqarnas, the elements have to be assigned adequate materials and textures. According to Harb, the elements were typically cast in plaster; one could also imagine some kind of clay.

Before trying to create a new material, I examined a very good material library for Blender, the *matlib_v102*. It already contained some suitable materials, the best ones being *stone_concrete* and *stone_sandstone* (even if these might not be a traditional muqarnas material, they look fine with the elements). From *stone_clay* I derived a new material, which can also be seen in the figure. Nevertheless, I decided to use two sorts of sandstone material (white and red) for the example muqarnas.¹

The inner faces of cells are usually textured in some way, either by paintings, tiles or reliefs. For this project, the IWR provided three previously scanned and composed textures which I applied to the faces by UV mapping. Before that the faces had to be prepared. A problem occurring with the cells that had been extruded was that the selected faces did not end at the inner edge, but reached into the cell, resulting in distorted and incompletely visible textures. The only solution I found was to cut these faces along the inner edge using Blender's Knife Tool. After this step (which is admittedly a little bit tricky) it is possible to select only the visible faces. Since these are many small slices, it may be convenient to join the slices on each side (Edit Mode: select faces + FKEY) so that one can select two large faces instead of all the parts.

¹At this point I wondered how new materials, which of course do not exist in any library, can be imported into a different Blender file. The solution is very easy: All .blend files contain several folders in which all properties of the created scene are stored. With "Append" from the File Menu (or SHIFT + F1), it is possible to select any .blend file, browse its folders and choose what one wants to import (objects, materials, textures etc.).

Texture mapping is a little bit more complicated, since it has to be done manually. Although Blender offers automatic mapping techniques, they are only appropriate for simple objects like cube, sphere etc. In our case, one only ends up with a distorted projection of the texture. Thus, I used UV mapping, which works as follows:

Select the two inner faces in Edit Mode, then switch to UV Face Select Mode. Open the UV/Image Editor in one of the split view windows (SHIFT + F10) and load the texture image. Move the mouse cursor over one of the windows in 3D View (the normal view). In order to map the image to the selected faces, the latter ones have to be unwrapped. There are again several options provided by Blender, but for me the easiest way seemed to be to rotate the mesh to a position in side or front view where the selected faces are clearly visible and upright, and then press UKEY and choose "Unwrap from window" from the pulldown menu. The UV map is now visible in the UV/Image Editor and has to be arranged on the texture. Vertices are best selected with the Box Tool (BKEY), because there are always several vertices overlapping which should all be selected together.

It is important that no texture is assigned to the material that the mesh is connected with. Instead, the "TexFace" button in the Material Tab has to be activated (otherwise the UV mapped texture will not be rendered!). In order to have a preview during the mapping process, one can choose "Textured" as display mode. At some point of time, the inner faces should also be smoothed: With the faces selected in Edit Mode, press the "Set Smooth" button in the Edit Panel.

4 Example Muqarnas

As examples I composed two muqarnas: One small vault which has three interpretations, and a vault in a niche of the Friday Mosque at Natanz. The important points here have already been mentioned above: To simplify the arrangement of basic elements, I used the muqarnas plans as background images in the top view window and added cells and intermediates level by level. Appending works the same way as with materials (SHIFT + F1, see above), only choose the "Plane.x" file in the .blend file's Object folder.

For screenshots of the rendered muqarnas see appendix.

5 Blender Evaluation

As far as I can judge from the experience of this project, Blender is a mighty program for visualisation and design, allowing for many adjustments of different

parameters. It already includes many functions and is also able to import and export several file formats. Since it is open source and supports Python scripting, modifications and extensions on all levels are possible. There is a large community of Blender users and developers offering fora and a real flood of tutorials, which makes it much easier for beginners to become acquainted with the usage of Blender. Moreover, many improvements are made in short time. Alone during the period specified for this laboratory, there were three new releases of Blender. The fact that Blender is available for many platforms is also a great advantage.

Nevertheless, some problems that occurred with the program should also be mentioned. For a novice, Blender is rather daunting and non-intuitive. The user needs to familiarise with many shortcuts (which often in fact are no fast possibility to access a function, but the only choice in order to achieve a certain result), complex menus, different modes etc. This is tedious at first, especially when using a notebook keyboard and touchpad, since numblock, function keys and three mouse buttons are needed constantly. But at sight of the first results one gets motivated to go further.

Concerning the construction of the basic side view, the lack of a possibility to define curve bending via angles turned out to be a problem. Using grid and Bezier curves, however, enabled a construction which might not be fully exact, but a good approximation. Besides, rotation and snap to grid would be easier if the pivots could be moved to a different point of an element. Although there is a function in Blender which promises to allow for this, I could not manage it. But this was of course no problem which would endanger the project, in contrast to several crashes of Blender during my work at the example muqarnas (simple crash of the program or OpenGL crash requiring a restart).

Despite the described difficulties, I am quite impressed of the results even a complete novice in the field can achieve with Blender. It needs some preoccupation with the usage and many tutorials, but I think the results are presentable. Maybe some of the problems I encountered might have been solved in a more elegant or adequate way by a person with more experience and background knowledge. It was possible, however, to come to a solution in most of the cases. The project showed that Blender is suited for muqarnas modelling, and I hope that even better results than the ones presented here will be achieved at the IWR in the future.

References

- [1] Harb, Ulrich: *Ilkhanidische Stalaktitengewölbe*. Berlin: Dietrich Reimer Verlag, 1978.
- [2] Takahashi, Shiro: *Muqarnas: a Three-Dimensional Decoration of Islamic Architecture*. [<http://www.tamabi.ac.jp/idd/shiro/muqarnas/>]
- [3] Muqarnas Visualisation at the IWR: Basic Geometrical Forms. [<http://www.iwr.uni-heidelberg.de/groups/ngg/Muqarnas/basic.html>]
- [4] Blender Website and Tutorials: [<http://www.blender3d.org>]
- [5] Blender Documentation Volume I: User Guide: [<http://www.mille.ca/mille/colibris/install/BLEND/doc/htmlI/book1.html>]
- [6] eYsiun Tutorials and Fora: [<http://www.elysiun.com>]
- [7] Tutorials from alienhelpdesk: [<http://www.alienhelpdesk.com>]
- [8] Blender Materials Database:
http://www.geocities.com/pollythesheep/matlib_tutorial1.html

A Appendix

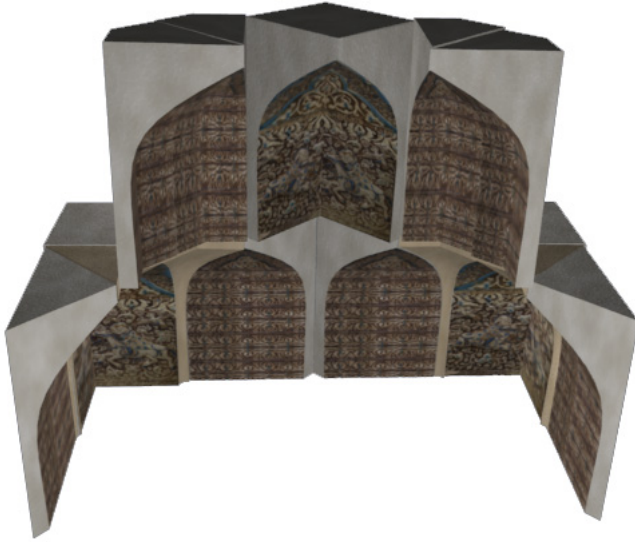


Figure 10: Vault 1, first version

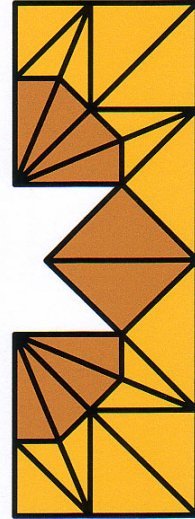


Figure 11: Vault 1, first plan



Figure 12: Vault 1, second version

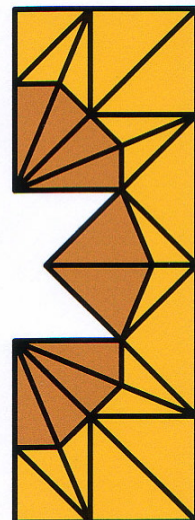


Figure 13: Vault 1, second plan

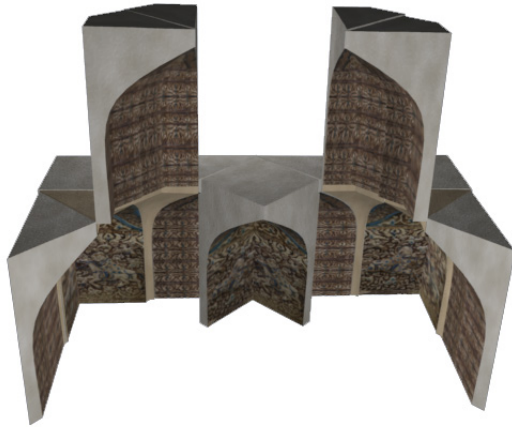


Figure 14: Vault 1, third version

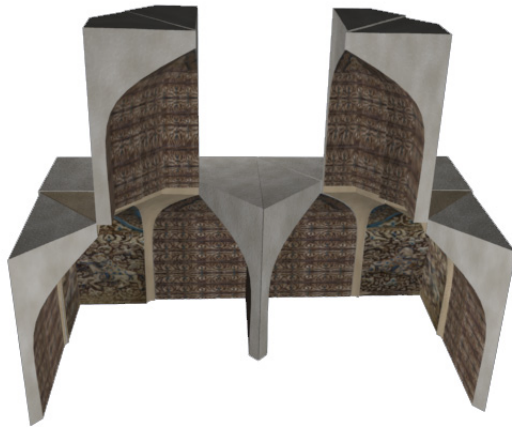


Figure 15: Vault 1, imaginable fourth version

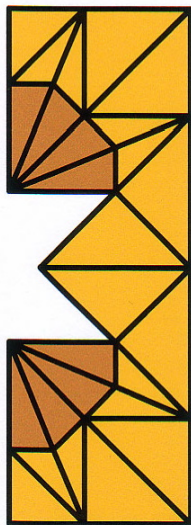


Figure 16: Vault 1, third plan



Figure 17: Vault 2, first screenshot



Figure 18: Vault 2, second screenshot

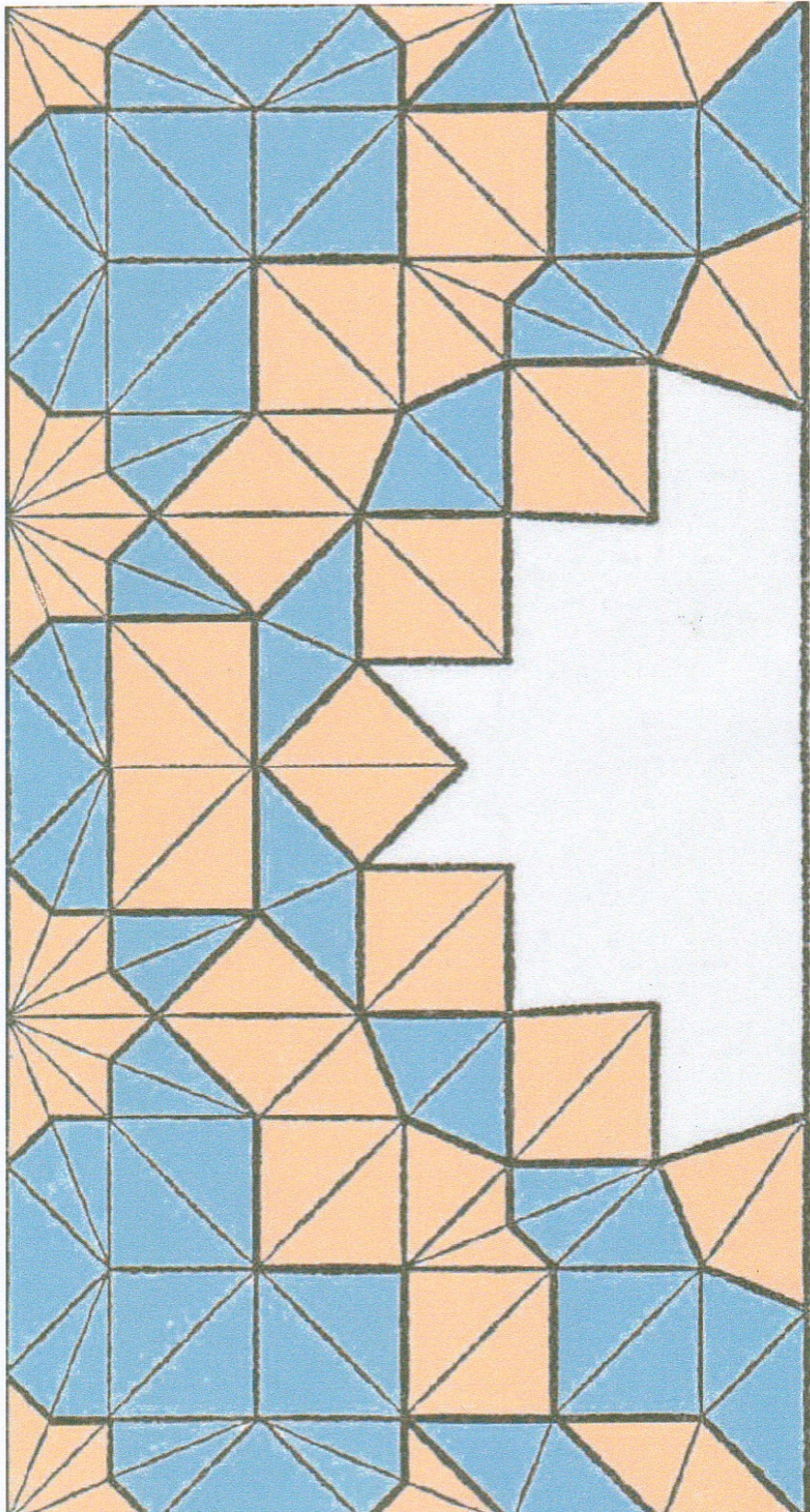


Figure 19: Vault 2, plan