# Inout Sculptures

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## Abstract

In this paper, we present a set of high genus virtual sculptures which we call inout sculptures. These sculptures are obtained by showing both **in**side and**out**side of a shape with holes. Inout sculptures looks interesting since they allow to simultaneously view both inside and outside of complicated shapes.

## 1 Introduction and Motivation

The people innately find a mysterious beauty in sculptures with smooth saddle regions, which we call hyperbolic sculptures. well-known examples such hyperbolic sculptures are Robert Longhurst's Arabesque 29th [9] and Brent Collins's hyperbolic sculptures with many smooth holes and handles [19]. In this paper, we present a simple method to create hyperbolic sculptures. Our idea is simply to simultaneously show both inside and outside of an already complicated shape that contains many holes. An example of an inout sculpture is shown in Figure 1.

**Figure 1**: Yutu Liu's 3D printed physical Inout sculpture.

Akleman, Srinivasan, Mandal and Chen introduced several methods to create high-genus surfaces such as rind modeling [5], column and wire modeling [18] and multi handles. Using these methods, it is possible to easily create complicated shapes with many holes and handles, which we call high genus sculptures. Both insides and outsides of these sculptures are interesting. In this paper, we present a method to show both inside and outside of these sculptures. The method is simultaneously discovered by both Yutu Liu and Hernan Molina during Computer Aided Sculpting course. They both wanted to show inner beauty of the sculpture they have already created. By showing the inside of the sculpture, they ended up new kind of sculptures they look more interesting than their initial sculptures. I, Ergun Akleman, realized that they have discovered a new way of creating sculptures and I have created a series of virtual sculptures starting from platonic solids. Those sculptures also turned out to be interesting. Thus, we decided to report our findings.

## 2 Methodology

The method consists of five steps:

1. We start with a simple mesh such as cube, dodecahedron or toroid.
2. We apply a high genus modeling operation to the mesh. There are four operations that can be used. The Figure **??** shows the effect of each operation.
   (a) Column Modeling
   (b) Wire Modeling
   (c) Merger Sponge
   (d) Multi-Handle
3. Apply ”Doo-sabin” operation on the selected object.
4. Apply ”Rind Modeling” on the selected object.
5. Select pieces from the surface to remove.

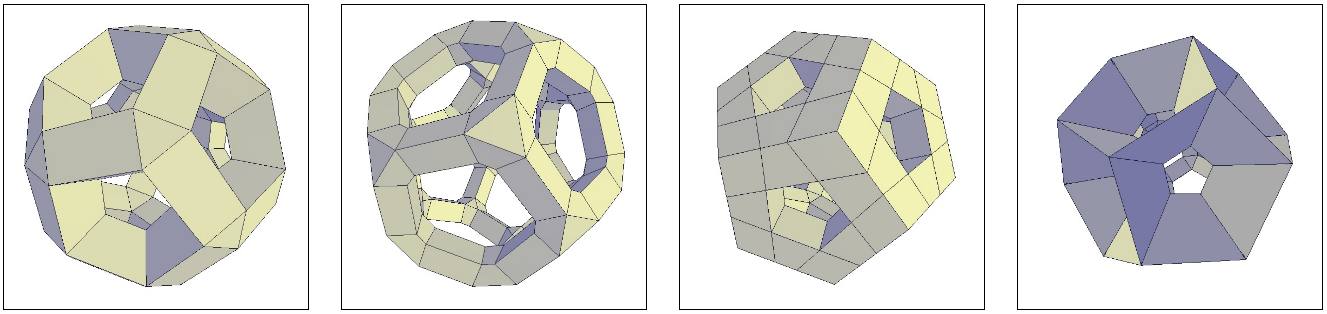
”Column Modeling” is a very neat feature in Topmod. The algorithm behind this operation is that it replaces each edge with a column and creates ”joints” to connect ”columns”. The shape of ”joins” is determined by the thickness and cross-sections of ”columns.” In addition, segments and thickness can be used to obtain smooth objects. More information about ”column modeling” can be found at [1]. ”Doo-Sabin” is a subdivision scheme to obtain smooth geometries, which generates new meshes based on midpoints of old edges and centroid of old meshes. ”Rind Modeling (Thickness)” is an interactive operation inside Topmod, which create a crust for peeling or punching rinds.

Of course, you probably need to play with the ”thickness” and other parameters to obtain the best results. Now we are ready to remove pieces to create the inside-out look. In many cases, you probably need to remove a large number of small pieces to have the finished object. From my personal experience, it’s better to just throw away many small parts; therefore it will give you a well-defined object. Again, it’s up to your personal preference. After you have done the job, the finished product should be like the one in figure no

You can work on many objects to create a series of inside-out-look surfaces. So far we have tried creating many of them using objects like torus, soccerball, tetrahedron, icosahedron and dodecahedron etc. We have found that those created objects are surprisingly beautiful and elegant in the sense of their geometrical shapes. Furthermore, this concept is not only limited to ”column modeling,” it should also work for other similar operations in Topmod such as ”wireframe” etc. At last, we want to give a name for the series objects. So does ”inok” or ”inouk” ring the bell for you? Or you have a better idea?

## 3 Implementation and Results

We have implemented our method in an interactive modeling system developed using C++, OpenGL and FLTK[11]. The method works best when it is applied to the multiple faces of convex meshes such that the collection of the selected faces covers all the vertices or the convex mesh. For instance, by selecting only three faces of a cube, we can include all vertices as shown in Figure **??**. If all the vertices are chosen, the convex hull created by these vertices will be closely related to the initial convex shape and it will provide nice handles. The Figures **??** and **??** show triple, quadruple, pentuple and hextuple hole structures that are created by applying multiple hand operation to a cube and octahedron respectively.



Wire Modeling | Column Modeling | Merger Operation | Multi-Handle

**Figure 2**: High Genus Operations.

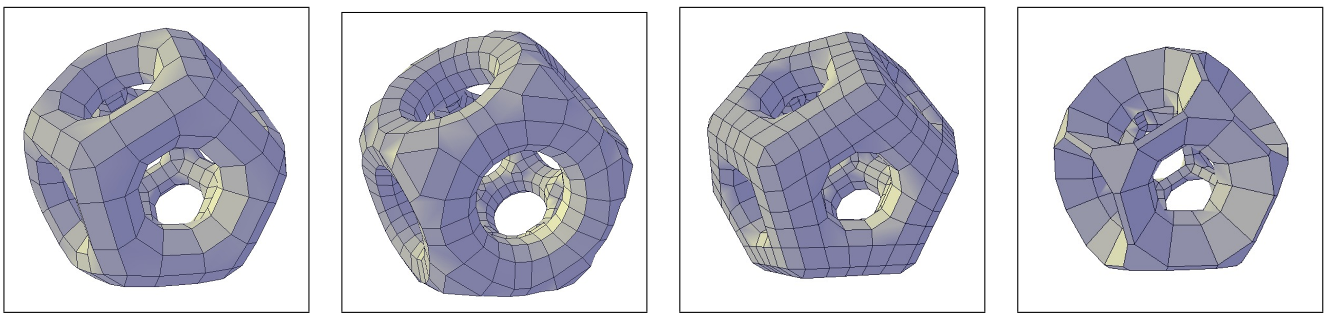


**Figure 3**: Doo-Sabin Smoothing.

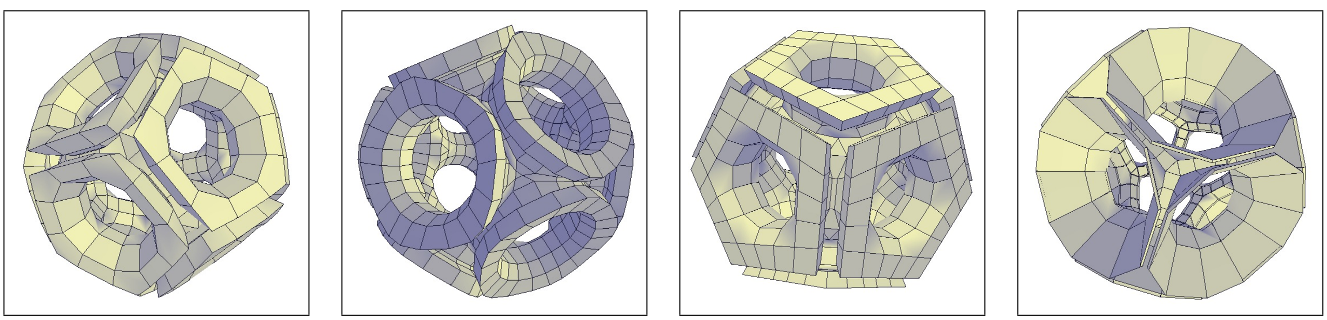


**Figure 4**: Rind Modeling.

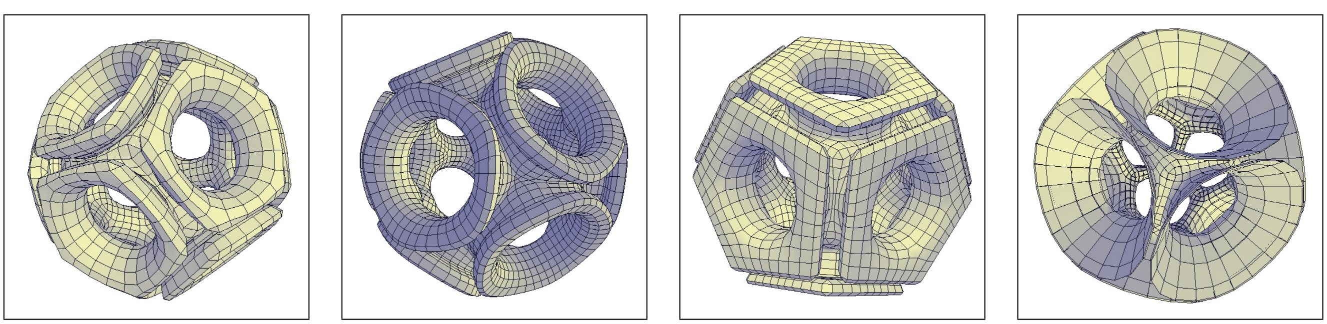


**Figure 5**: Doo-Sabin Smoothing.

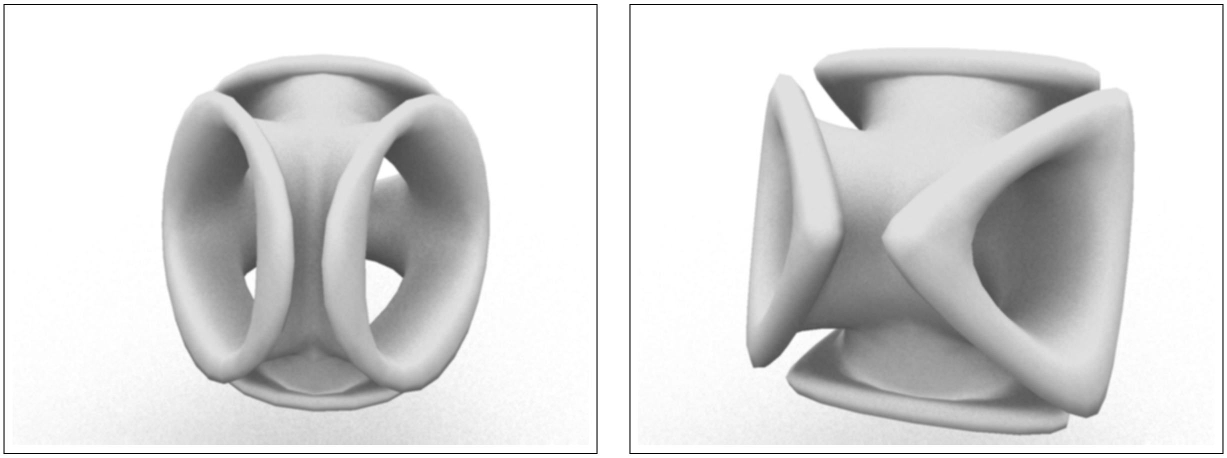


**Figure 6**: Ergun Akleman's Virtual Tetrahedral Inout Sculptures.

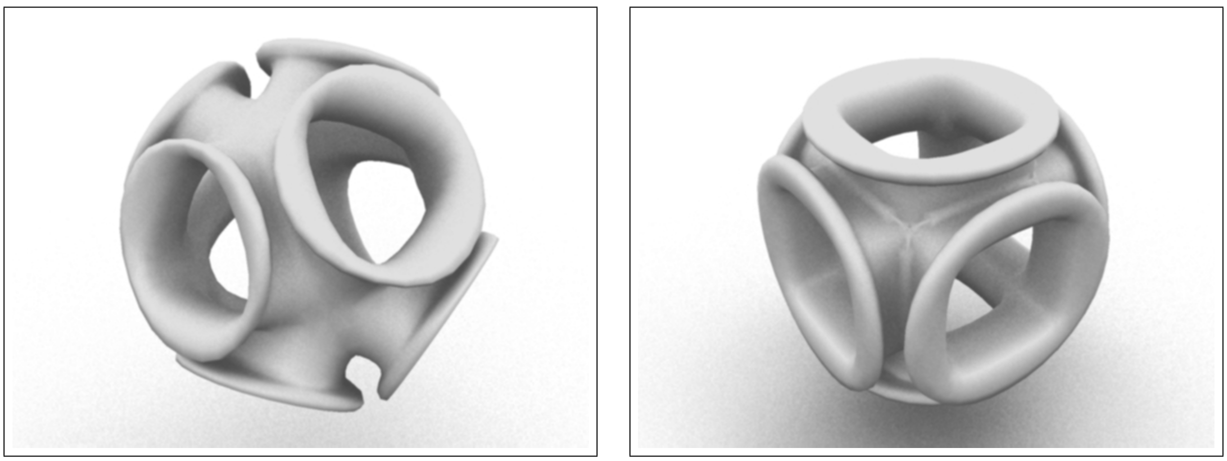


**Figure 7**: Ergun Akleman's Virtual Octahedral and Cubical Inout Sculptures.

## 4 Conclusion and Future Work

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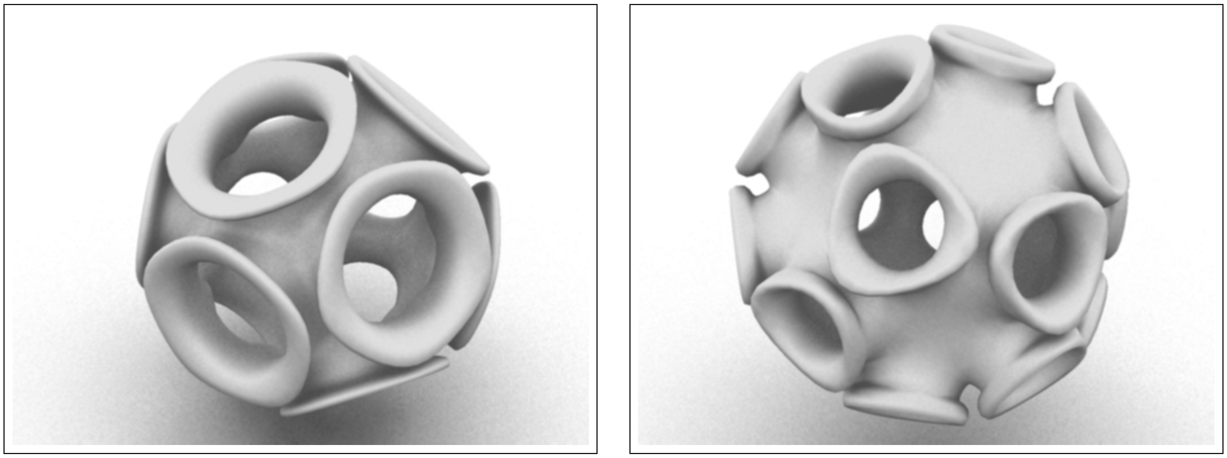

**Figure 8**: Ergun Akleman's Virtual Dodecahedral and Icosahedral Inout Sculptures.

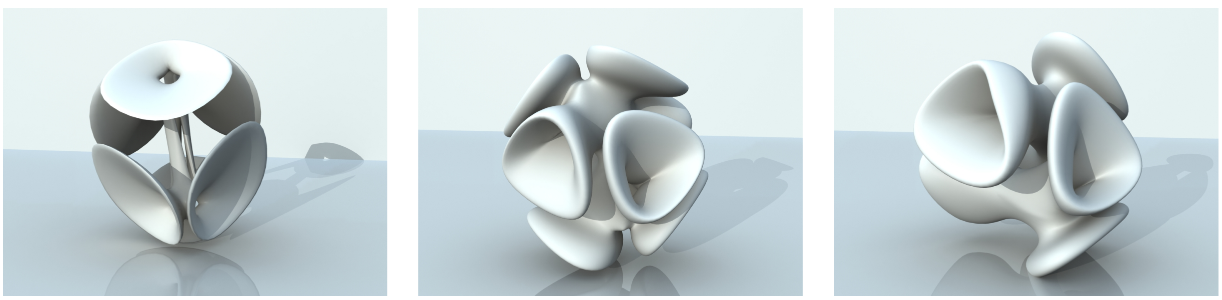

**Figure 9**: Hernan Molina's virtual Inout sculptures. Inital mesh is crated by using creating two triple handles.)


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**Figure 10**: Hernan Molina's 3D printed physical Inout sculpture. See the right virtual sculpture in Figure 9. )


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