

Interactive 3D Rapid-Prototyping Models

Carlo H. Séquin
U.C. Berkeley, EECS, CS Division

Making Truly Interactive 3D Models

- ◆ Not just virtual displays that can be twiddled with a mouse.
- ◆ But tangible 3D models that can be physically manipulated.
- ◆ Dissection puzzles are excellent tutorial examples:

Instructional / Educational Value of 3D Dissection Puzzles

Used in course on Solid Modeling & Rapid Prototyping:

- ◆ The design of the 3D puzzle geometry requires spatial visualization skills.
- ◆ The design of the physical artifacts requires attention to tolerances and to materials properties.

Tangible Models

Provide relevant feedback on whether parts fit together and have the right amount of resistance to movements:

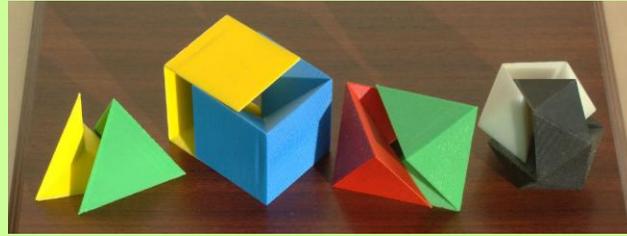
- ◆ so that they don't fall apart by themselves;
- ◆ so that they don't stick too tightly together.
- ◆ Success is judged by manipulating the model.

Play with the models !



Dissection Geometries

A Simple Introduction to Polyhedral Dissections

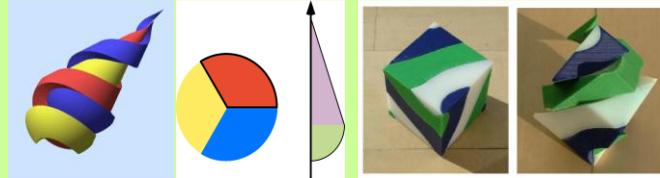


Hamiltonian dissections of Platonic Solids: The cutting surface is formed by a line sweeping from the centroid of the solid along a Hamiltonian cycle on the polyhedron edges.

Helicoidal Dissections

Problem Statement:

Design a two- or three-piece geometrical puzzle in which a simple shape partitions into all congruent parts via a helical screw motion.



A first approach: Define one or more helicoidal cutting planes around the z-axis and use those to cut up a shape with proper rotational symmetry around this axis.



A second approach: Define the extrusion of a suitable cross section and its complement; Helicly twist the whole configuration around the z-axis.

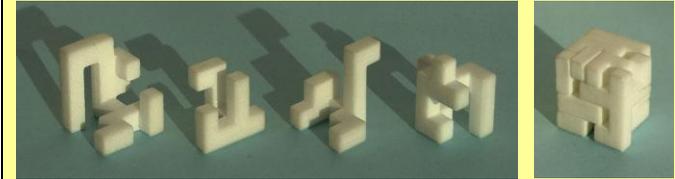
Multi-hand Dissections



In this ring of 5 tiles at least 3 tiles have to be moved simultaneously in different directions in order to take this puzzle apart.

Fabrication Issues

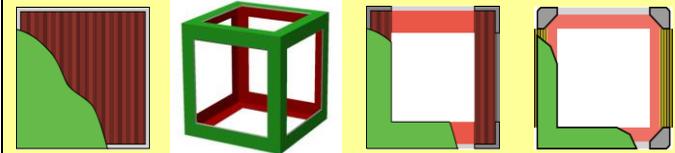
Interlocking Cubic Burr Puzzle



Problem Statement:

Here is a picture of a neat cube-dissection puzzle. We would like to have one like it, -- but at a much bigger scale (say, scaled up by a factor of 8 or 10)! Find a design that can be built at this larger scale in an economical way with a layered manufacturing process.

Solution: Use a grid / frame approach to outline each unit cube:



Possible cubelet designs: (a) cross section through a hollow cube shell; (b) Leonardo-style cube frame; (c) cross section through this cube frame with support structure (dark vertical lines); (d) final cubelet frame design with beveled edges.



(a) One frame part as it comes out of the FDM machine; (b) another part after removal of the support structure; (c) the whole 4x4x4 burr puzzle assembled.

Tolerances !



Too tight ??

Dissecting All of 3D Space



Isohedral helicoidal tiles (Matthias Goerner)