Digitally Spelunking the Spline Mine

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Abstract

The Spline Mine consists of unique representations of polyhedral domains produced by: 1. modeling the solids variously classed as: Platonic, Archimedean, Catalan, Kepler-Poinsot and Stellated Icosahedra; 2. projecting polyhedral surfaces onto a plane to produce linear maps; 3. converting these maps to symmetrical spline curves; 4. using these curves for the creation of derivative forms. These curves are painted, extruded, lofted, projected and blended to produce a range of forms including: 2D prints and animations; and 3D channels, bas-reliefs, and domes.

1. What am I trying to do?

1.1. Digital or Analog? In Buckminster Fuller's *Universal Requirements for a Dwelling Advantage: Realization by Design* [5] he outlines the Individual and Collective responsibilities of design scientists in the production of artifacts to improve the survival advantage of humanity. This paper is my overture to the "Collective", hopeful that the Spline Mine can contribute to our understanding of the universe and our survival. The scientist in me hopes that the Spline Mine is an analog of physical processes. The artist in me appreciates the beauty of these digital representations; the beauty in numbers.

1.2. Naiveté. Following Fuller's dedication to H.S.M. Coxeter in *Synergetics* [6] he encourages the reader to "Dare to be naïve". I accepted his dare and in 1976 wrote him suggesting his Geoscope concept could be realized by a small dome studded with light emitting diodes. One pixel would represent 4250 sq. km. of Earth, a woefully inadequate scale for cartography. Even so, Fuller replied with an enthusiastic letter that suggested the computer control could be accomplished through 1/120 of a sphere, its maximum equal subdivision. I used his suggestion in my design thesis [8] by attaching a dihedral kaleidoscope [2] to a computer monitor. With three mirrors I created an analog spherical display with 20 million pixels of dynamic colour. This device, though not appropriate for displaying Earth resources data, inspired a study of rotational symmetry. While modeling polyhedra that can be displayed with these instruments I encountered the vexing Necker Cube problem (Fig. 1), the failure of mind to differentiate foreground and background of symmetrical objects. With no depth cues in early CAD software, the Necker illusions caused endless frustration during model construction. Ironically, what had started as a project of scientific visualization had become bogged down in the limits of human vision. The wire frames were difficult to read as solids but they were visually appealing and worthy of some flatland musing. I had turned away from grand geopolitical visions toward the 'preponderance of the small'.

1.3. A User's Life. I first encountered computers in 1972 when I created a table of geodesic dome chord factors. While an undergraduate I experienced the horrors of punched cards and assembly language. In 1979 I was intent on playing Fuller's 'World Game' on a CPM computer with 48K ram. Oh so naïve! It became apparent that the computer's insatiable demand for detail made computing difficult. In an industrial setting I learned the formalisms for providing that detail, specializing in CAD. With each CAD encounter I would create representations of Fuller's geometry that eventually evolved into the Spline Mine. It is the result of a user's life, enabled and limited by tools developed by others; a life spent sitting for hours adapting to software rituals, the babble of the machine.

1.4. The Spline Mine. I discovered the Spline Mine on a quest to colour polyhedral projections using software. Rhinocerous ® nurbs modeler and the Corel ® suite of graphics programs enabled this quest. The 3D solids were modeled in Rhino (Fig. 2) then their surface edges were imported into Corel as sets of closed 2D polylines where they were converted to symmetrical spline curves. Without parallax the surfaces parallel to the 3D axis of view are visible in the 3D models only as lines. If included in the 2D data, these lines introduced undesirable kinks and were excluded. In Corel the 'convert to curve' command changes polylines by adding a curvature parameter to their end points, now called nodes. The resultant curve is a combination of the parent solids' foreground and background surfaces, easily coloured. I call these **Cyclons.** The most interesting cyclons are generated from 3D views aligned with the principal axes of symmetry of the parent solid (Fig. 3). These curves can be read as overlapping sets of ellipses where odd numbers of overlaps produce filled regions and even numbers of overlaps produce voids. In views where foreground and background are the same, only half of the polyhedral surfaces are used, thus avoiding an 'empty' curve. From a finite set of solids an infinite set of unique subdivisions of a disc are possible by combining multiple cyclons.

1.5. Animations. Animations were created using the Corel Rave 'blend sequence' command, operating on pairs of curves. When a cyclon is duplicated and its nodes aligned to a point this new curve's nodes have identical spatial coordinates but vary in curvature. Call it an **Anti-Cyclon**. When the cyclon and its anti-cyclon are assigned key frames in a sequence, the resultant movies, **Cine-Cyclons**, transform smoothly, unlike the disjointed transitions between unrelated curves (Fig. 4 & 5). The cine-cyclons suggest: a collapse to an event horizon, the pulse of a dynamic field, or a journey through a worm hole.

1.6. Derived Forms. To derive 3D forms from these curves it is useful to define the curves as surfaces and the voids as objects. By assigning a line weight to the curve the 'convert outline to object' command produces a recognizable surface or **Frame**. By 'breaking apart' the frame the voids are transformed into **Portals** (Fig. 4). Portal definition was difficult because: the high incidence of tangent intersections produced complex figures that are prone to error and depending on line weight, varying numbers of portal objects are created, many too small to be useful. Manually corrected these portals were exported to Rhino, extruded, lofted and projected to surfaces. The new 3D forms: domes, channels and bas-reliefs can be output directly to a 3D printer (Fig. 6, 7, 8).

1.7. Tailings. Recently I organized my drawings for a slide show. At 6 seconds per frame the previous 10 years work would play out in about 4 hours. Since then I have added animation to my tool set. A plot of frame creation over time shows exponential growth. With the potential to produce an infinite set of strangely attractive curves new problems arise: How do you organize this 'design space' [4] in order to navigate it, assign or extract meaning from it? Is there any practical application? Smith [9] points out that in the historical record of metallurgical artifacts, technique finds first application in decoration. Perhaps that is all I can expect of my work, though it is fun to speculate that these objects might inform a study of nanotech, proteomics, string theory or optical computing. If only I knew the math! Paraphrasing Galbraith [7], 'each generation is responsible for the re-creation of society' and Calhoun [1], 'each doubling of human population requires a doubling of conceptual space, a revolution, such that the newcomers might make a home'. In Calhoun's scheme of historical revolutions we are alive in the electronics age, perhaps more aptly called the communications age where old dualisms find mathematical expression as: information and entropy; digital and analog. Somewhere in the conceptual space between the "tetrahedron and the sphere" [3] I have dug a mine inside Plato's cave where I can be found organizing my bits, encrypting a message for Fuller's design science revolutionaries: collectively we can build a world supportive of Calhoun's 'compassionate revolution', expected soon.

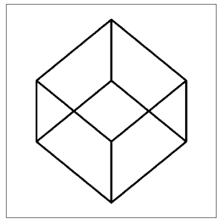


Fig. 1 Necker cube illusion

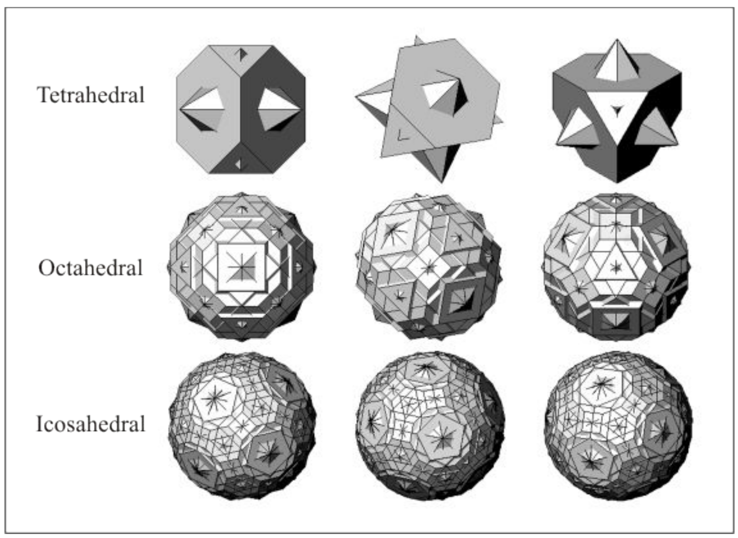


Fig. 2 Unit radius polyhedral families about common origins

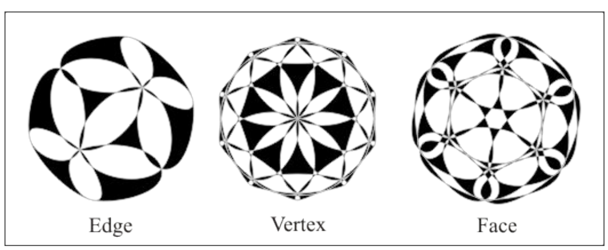


Fig. 3 Icosahedral cyclons from principal axes

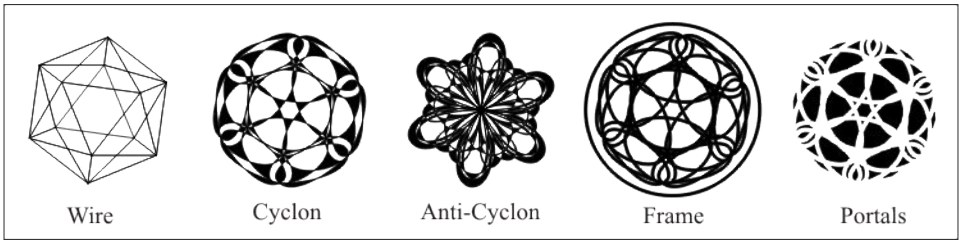


Fig. 4 Spline Mine component derivations

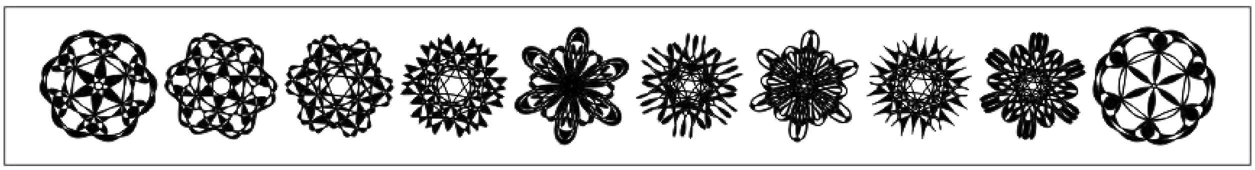
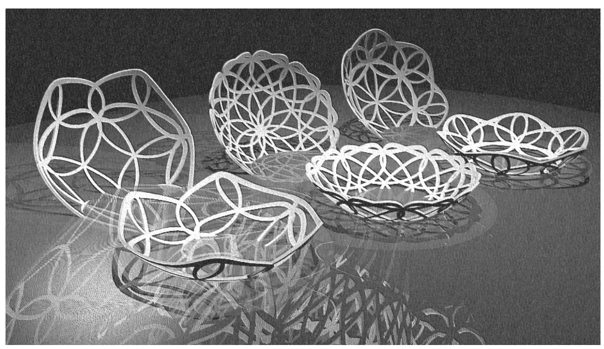
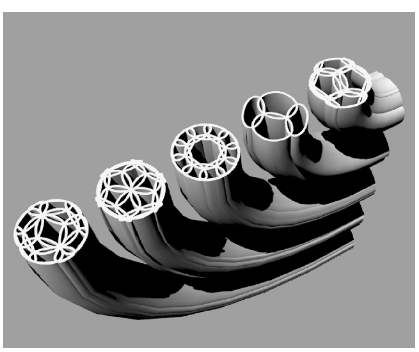


Fig. 5 Key frames in an icosahedral cine-cyclon





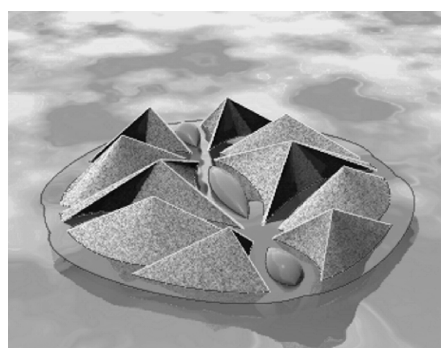


Fig. 6, 7, 8 Derived forms: domes, extrusions & bas-relief

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