PoCo

Polyhedral Computing V1.0, XColony Game Systems © 2017-2019

User Notes

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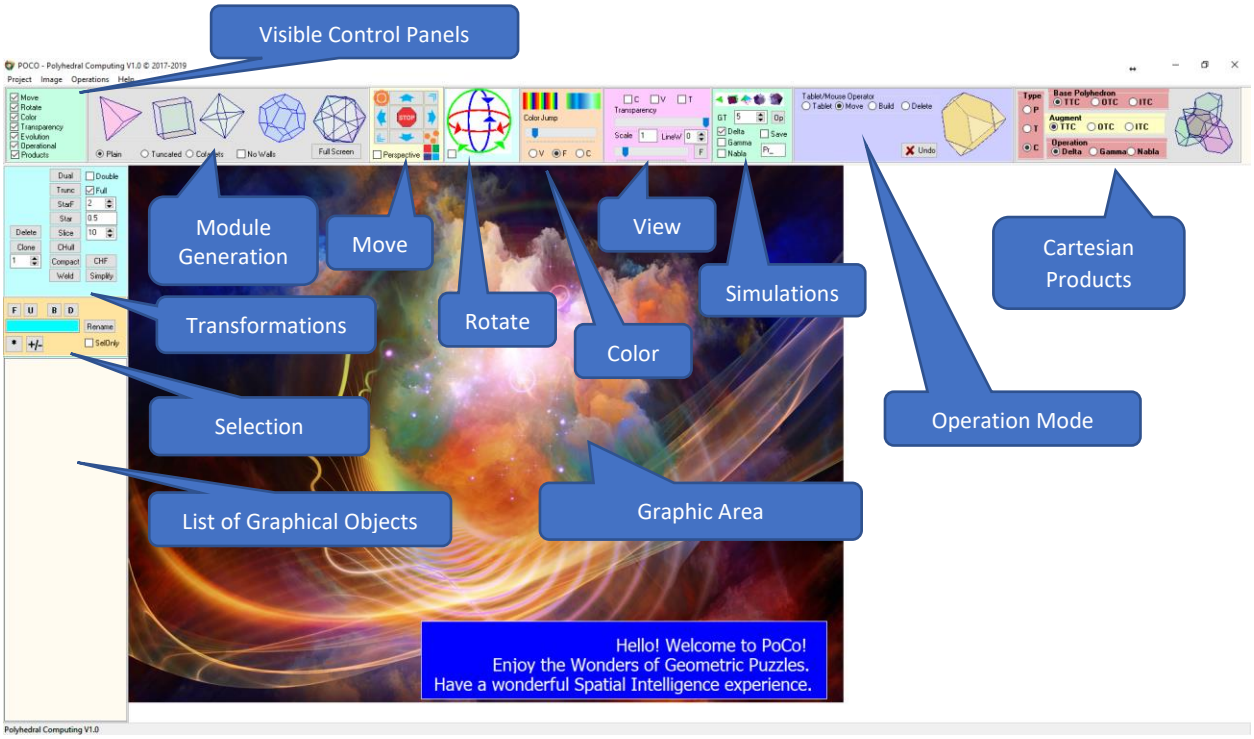
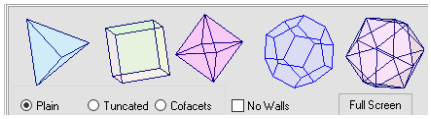
• Main Interface



Bookmarks. Basic Movement Rotation Coloring Display_Options Evolutionary_Algorithms Mouse_Operator_Mode Cartesian_Products Geometric_Transformations Object_Management Operations Additional_Features Special_Projects Videos_on_Youtube Appendices: A B C D

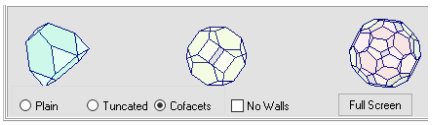
• Basic Module Generation



Click on upper comer images to generate a specific module.

(**Plain** option for Platonic solids: T, C, O, D, I modules)

(**Truncated** option for TT, OT and IT modules)



(**Cofacets** option for TTC, OTC and ITC modules)

Option: With/without interior walls.

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

These actions (mouse left click) generate elementary modules designated as follows:

1. The first character in the name of a basic module designates the Platonic solid that is represented:
   - **T** – regular Tetrahedron
   - **C** – cube
   - **O** – regular Octahedron
   - **D** – regular Dodecahedron
   - **I** – regular Icosahedron

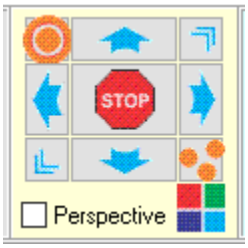
2. The second character "T" stands for **Truncated**

3. The third character "C" indicates that modules have the empty faces represented as virtual faces, called **Cofacets** (they exist but are visible only when the **C** checkbox on Display Options is checked).

See **Appendix A** for the complete list of the **Basic Modules** that can be generated.

Note. Mouse right click will select the active object in **Operation Mode**.

• Movement



Use **Arrows buttons to** assign movements to the Graphical objects selected on the list on the left. Use **Stop** to cancel all movements.

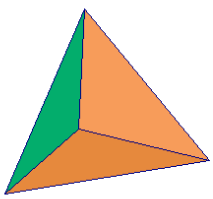
Corners buttons assign movement in perspective. This is visible only when **Perspective** is checked.

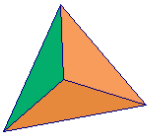
 moves all selected objects in the center of the graphical area.

 moves the selected objects at random positions.

 creates a graphical index view of all selected objects.

If **Perspective** is checked the depth information of the objects is visualized.

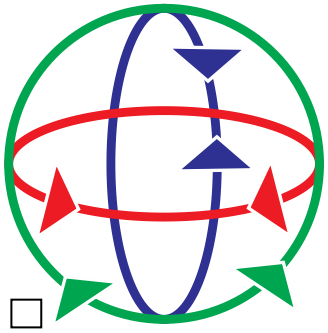




Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

• Rotation

Click arrows for rotation movements:

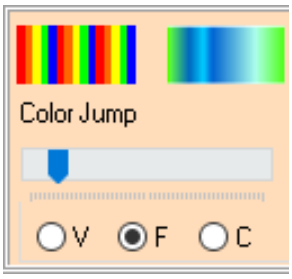


- upwards
- downwards
- left
- right
- clockwise
- counterclockwise

Note. Check the **Slow box** on the left bottom corner for lower speed.

• Coloring

There are two algorithms for generating colors:

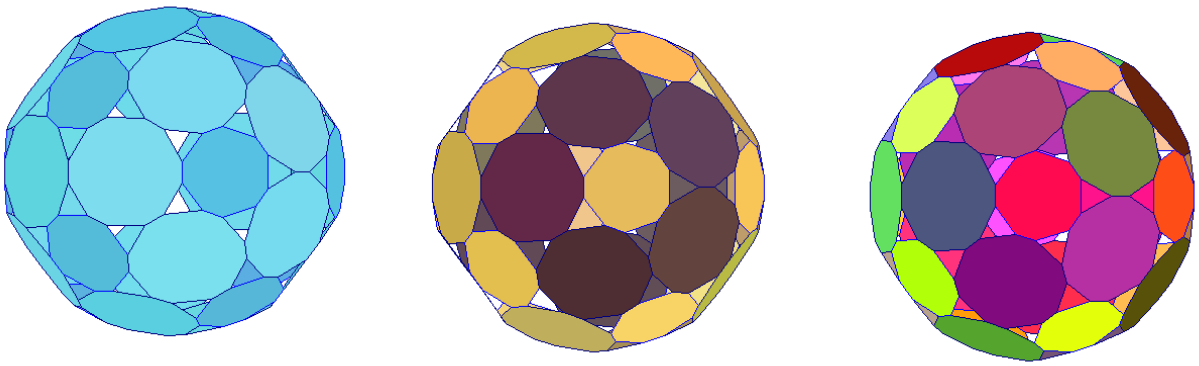


- Recolor (left)
- Color close (right)

The **Color Jump** sliding bar defines how close are colors in the palette. For instance, if **Jump** equals one, only one color will be used (no jump).

V (vertices), **F** (facets) or **C** (cofacets) specify what components are colored.

The images below illustrate **C** coloring with various jump parameters.

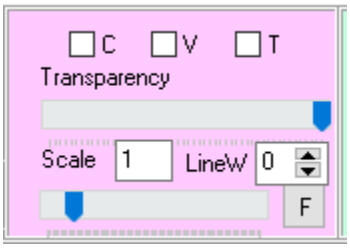


Color Close coloring with jumps: 10, 50, 200

The colors can be change deterministically using the dialog from Operations/Color (F4).

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

• Display Options



C – show cofacets

V – show vertices

T – visualize trace

Transparency level can be set from invisible to solid.

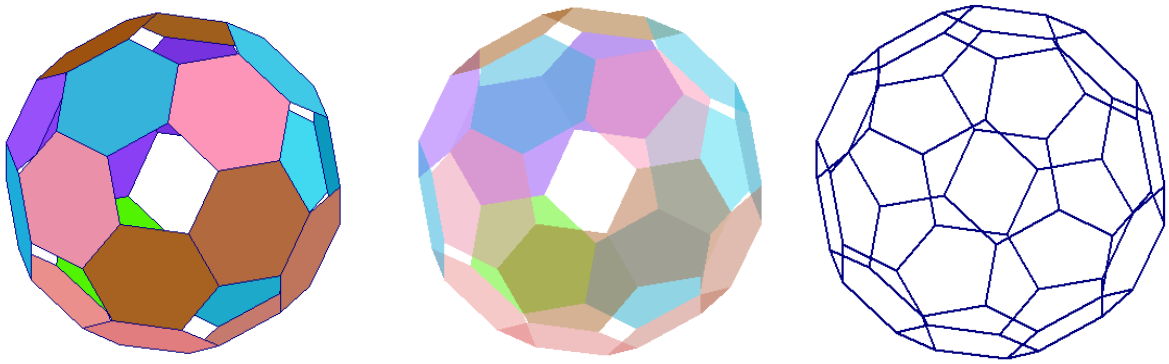
Scale is used for zooming in and out.

LineW – line width (between 0 and 10 pixels)

F – Fit size

6.1. Transparency

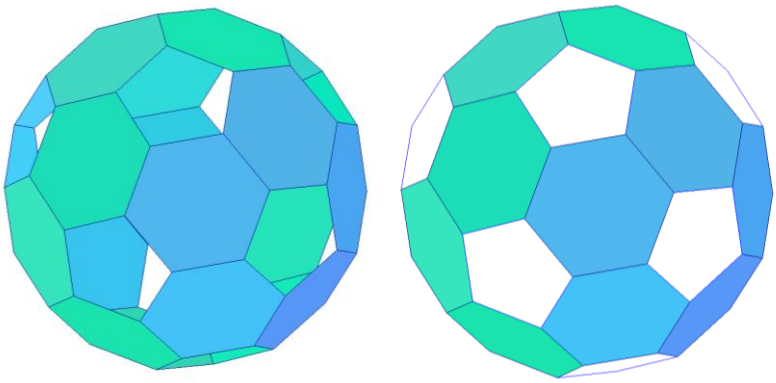
Full body, 50% transparency and wireframe views of an ITC module can be selected from the transparency **sliding bar**, as shown below.



ITC module (Full body, 50% Transparent, Wireframe)

6.2. Display Cofacets

When **Show Cofacets (C)** is checked the objects with cofacets will display them.

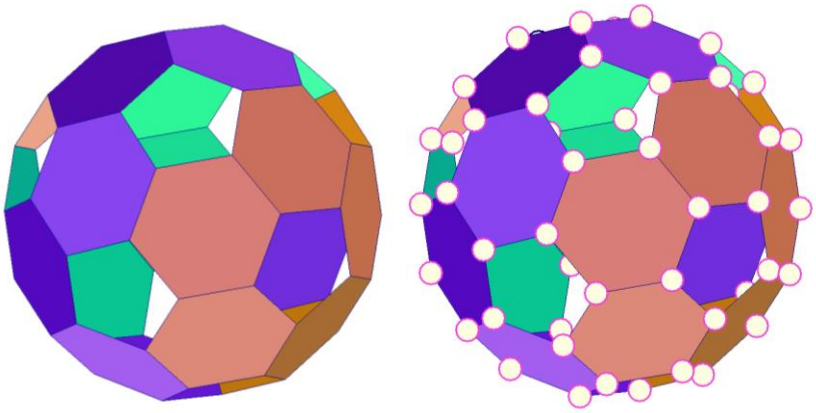


ITC module (simple and with cofacets)

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

6.3. Display Vertices

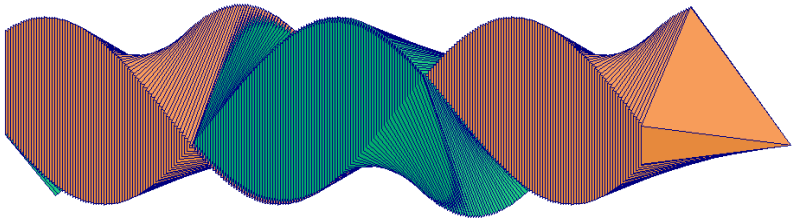
When **Show Vertices (V)** is checked the modules will display their vertices.



ITC module (simple and with vertex view)

3.4. Persistent Trace

When **Trace** is checked the trace of the moving modules remains visible.



• Evolutionary Algorithms

The **Op** button selects randomly two graphical objects and tries to apply the operations that are checked: **Delta**, **Gamma** and **Nabla**. See **Appendix B** for a complete list of the results that can be obtained by applying these operations to basic modules.

Click on **Evolution** (top image) to apply iteratively random joining operations until it produces one complex graphic object or cannot advance anymore. **GT** specifies the generation time. GT = 1 is the fastest.

Check **Save** and specify the **Prefix** below if you want that generation instances to be save as bitmap files. You might want to do this if you plan to make a movie or use the pictures you save. Otherwise is just generates many files. Use this option wisely.

See **Appendix C** for two illustrative examples of **Evolutionary Simulations**.

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

• Mouse Operator Mode

There are distinct operational modes that can be applied to tablet/mouse events:

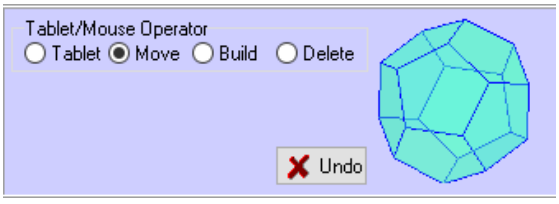
- **Tablet** – can use touch screen
- **Move** – use mouse events to move object
- **Build** – use mouse events to append ones
- **Delete** – delete object components (vertex, facets and cofacets)

8.1. Tablet Mode

There are several available gestures that can be used in tablet mode and with similar mouse events:

- **Move**:
  - left
  - right
  - up
  - down
- **Rotate**:
  - Around the **vertical** axis:
    - < – Chevron left – left rotation
    - > – Chevron right – right rotation
  - Around the **horizontal** axis:
    - ∧ – Chevron up – upwards rotation
    - ∨ – Chevron down – downwards rotation
  - Around the **screen center**
    - Clockwise right semicircle – Clockwise rotation
    - Counterclockwise left semicircle – Counterclockwise rotation

8.2. Move Mode



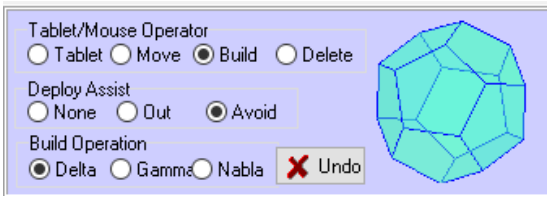
Mouse is active on the graphic area.

Left button click&drag will select the object and will move it to the destination.

Right button click&drag will assign speed and direction to objects. **Right click** while left button is pressed makes a copy of the dragged object in its current location.

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

8.3. Build Mode



The **Build Mode** allows appending new modules to existing graphical objects.

Used **mouse left click** to select the position to be processed.

The object displayed in this panel (default) is going to be appended to the selected position, by performing the operation specified in **Build Operation** selection.

The displayed object can be changed by:

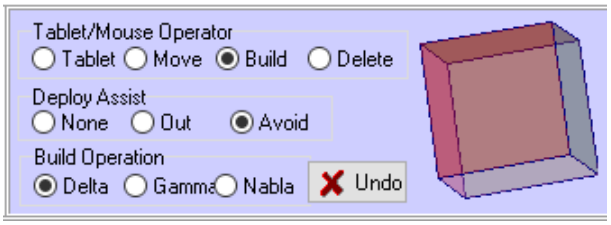
- Generating a basic module
- Right click on the generation images to change it to default
- Right click on the image in the **Cartesian Products** box to change it to default
- Double-click on one object in the list on the left of the main GUI. You may want to right click one face to define it as active (also you can use the **Operations** form).

The assistant tries to assist the connecting operations:

- The **Out** option will place the appended module away from the center of the selected object
- The **Avoid** option will place the appended module such without overlapping
- Keep **left mouse button** pressed to preview the operation
- If **mouse right click** occurs while mouse left button is pressed, the assistant change to a new operation and preview it. Successive **right button clicks** will flip and rotate to new configurations. The operation is completed when the **mouse left button** is released

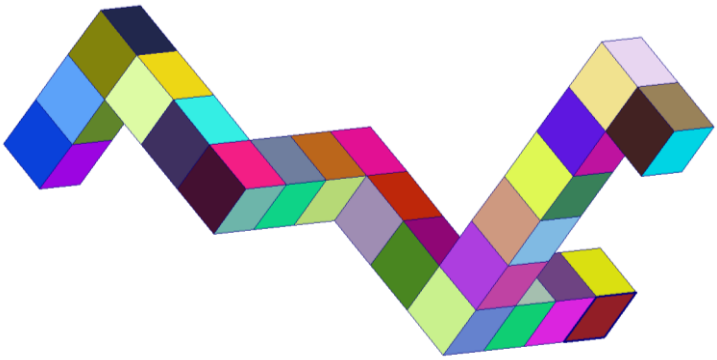
If anything goes wrong, the **Undo** button restores the previous configuration.

Example 1. Start with one cube, set the mouse mode parameters as shown below:

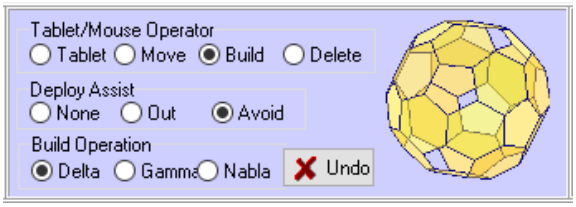


Every click will add a new cube to the existing ensemble, connected to the face that was clicked. The new element is added so that it avoids overlapping with existing elements of the ensemble (**Avoid** option is selected).

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

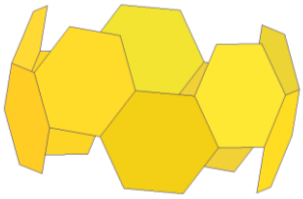


8.4. Delete Mode



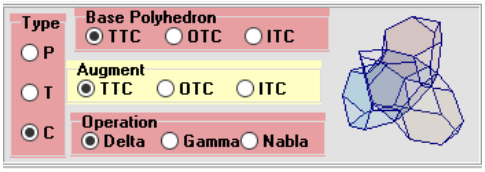
The **mouse left click** events select the element to be deleted according to the selected option in **Deletion Type**.

Example 2. Start with one IT module and delete the “polar caps” (one click at-a-time).



Build and Delete modes allows the last operation to be undone (Undo button).

• Cartesian Products



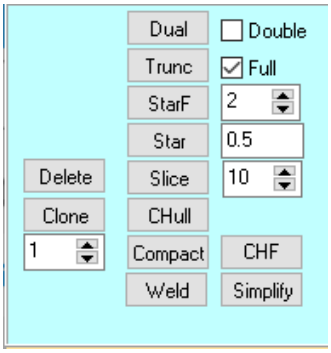
Select **Type** to specify the type of objects to be used. Select **Base Polyhedron** and specify in the **Augment** selection what object will *plaque* each face of the base. The object is generated by applying the specified **Operation**.

Use **mouse left click** on the image to generate the object in the general graphic area. This operation can be repeated many times. Use **mouse right click** on the image to set this object as default in **Operation Mode**. The generated objects will have assigned a **bonding face** and a **bonding vertex**, that are used in **Build Mode.** This selection can be changed from **Operations/Control** menu or **right click** events.

A complete list of the Cartesian products is presented in **Appendix D**.

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

• Geometric Transformations



Transformations are applied to single objects. Most of the transformations generate one new object. **Compact**, **CHF, Weld, Simplify** are in-place operations and **Delete** eliminates the object itself.

Dual – generates a dual object. If **Double** is checked it generates the dual of the dual.

Trunc – Truncation generates the truncated version of the object. If **Full** is checked the cofacets are used for dualization.

StarF – generates the star transformation of the facets. The parameter defines what kind of star polygons are used to replace the facets. For the value of 2, the vertices at distance 2 define the new edges.

Star – generates the star transformation of the polyhedron itself.

CHull – Convex Hull generates the convex hull as a union of triangles.

Compact – replaces adjacent coplanar polygons with their union.

CHF – converts the faces into convex polygons.

Clone – generates the specified number of copies

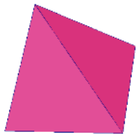
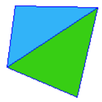
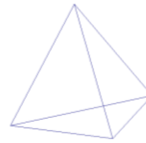
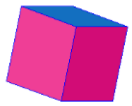
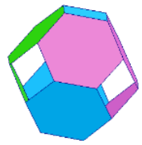
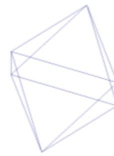
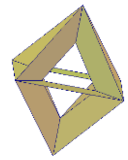
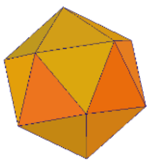
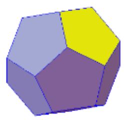
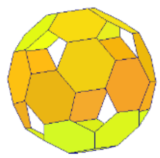
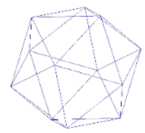
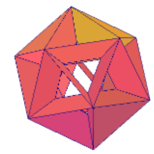
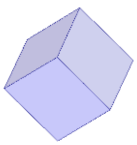
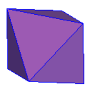
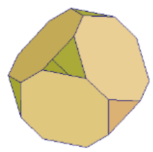
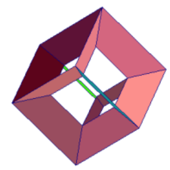
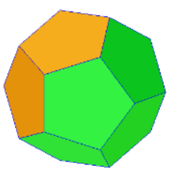
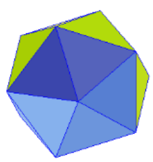
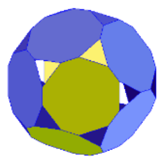
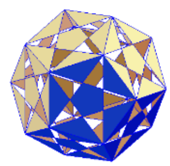
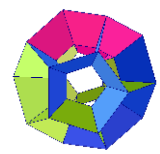
Weld – Identifies vertices with same coordinates

Simplify – Removes multiple copies of faces if they exist

10.1. Dual, Truncation, Starface, Star transformations

Dual transformations create new polyhedra by taking the center of existing faces and joining them if they correspond to adjacent faces; **Truncation** cuts all corners; **StarF** (Starface) converts all faces into stars; **Star** connects all edges with their copies placed towards the gravity center of the module.

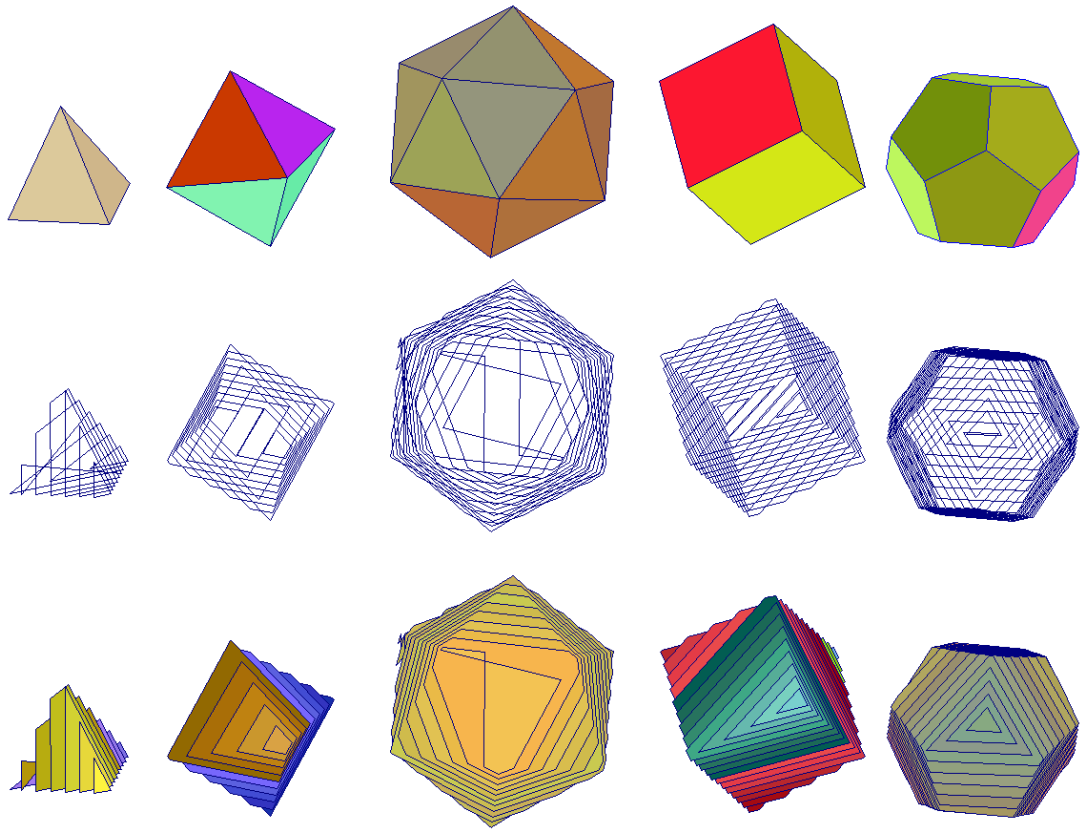
Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

Geometrical Transformations (T,O,I,C,D)				
	Dual	**Truncation**	**StarF(2)**	**Star (0.5)**
				
				
				
				
				

10.2. Slicing

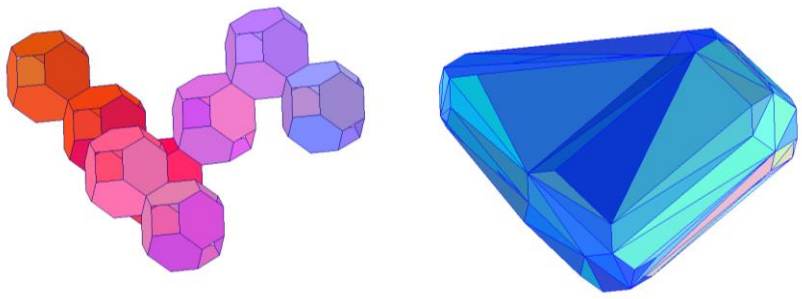
This transformation generates cross-sections of the original module with parallel planes in a specified number and creates a new object by joining these sections together. The picture below illustrates the **Slicing operation** of the five Platonic solids with increasing number of planes in wireframe and randomly recolored full body format.

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3



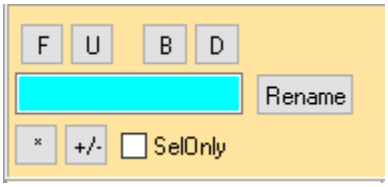
10.3. Convex Hull

Convex Hull is a transformation applied to the vertices of a module. A *gift wrapping* algorithm is used to generate the result. The picture below shows a complex module and its convex hull.



Optionally, the **Compact** and **CHF** (Convex Hull for Facets) operations can be applied to simplify faces of complex modules.

- **Object Management**



Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

Objects can be moved in the selection list. The objects are drawn on the graphic area in the order they appear in this list. They can be promoted or demoted using the following commands:

- **F** – to front
- **U** – up 1 level (the list is sorted from top to bottom)
- **B** – to back
- **D** – down 1 level

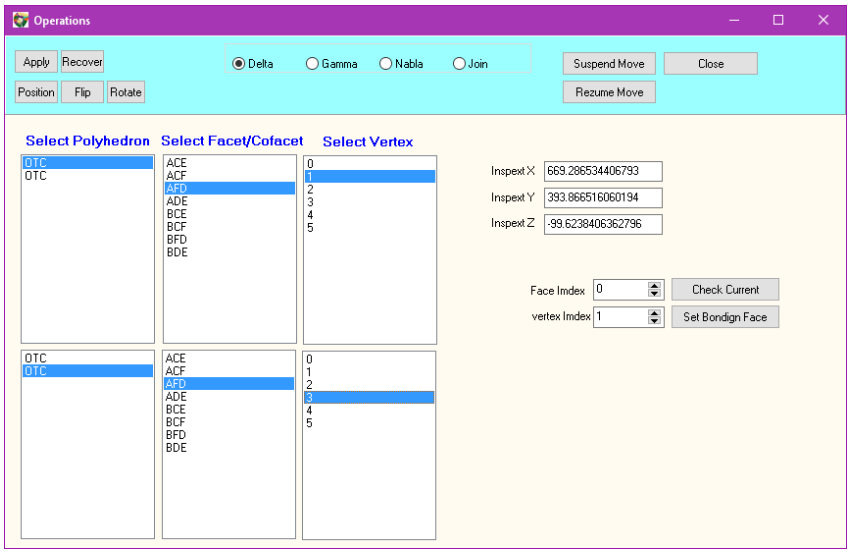
The cyan **Edit Line** can be used to **Rename** the current object.

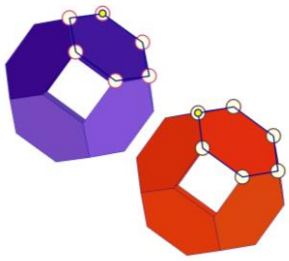
Click **"*"** to select all objects; click **"+/-"** to revert the selection. If **SelOnly** is checked all operations, including visualization, are restricted to this subset.

• Operations

The "Operations/Control" menu (shortcut F3) opens a form for performing operations with increased level of control. The operations dialog allows users to select the operands (elements, faces, cofacets and vertices) and the operation to be applied. The selection consists of specifying the two objects to be connected, the facets/cofacets that will be juxtaposed, and the vertices to be matched.

For example, the following selection specifies application of a delta operation to the O modules shown on the right.





Note. The **Join** operation is simply the union of two modules, without changing the geometry.

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

When the **Apply** button is pressed, the two polyhedra will be joint with the best match of the selection parameters. For advanced control, it is recommended to perform the connection operation as follows:

1. Click on **Position** button to preview the result
2. If the result is not what is expected, use the **Flip** button to reflect the second polyhedron with respect to its selected (co)face or **Rotate** button to reposition it
3. Press **Apply** to perform the connection
4. If result is not acceptable, try **Recover** the components (and delete the previous result)

When a vertex is selected for the first object the coordinates are displayed. The **Check Current** button identifies the bonding faces and vertices. To change this selection, use the **Set Bonding Face** button.

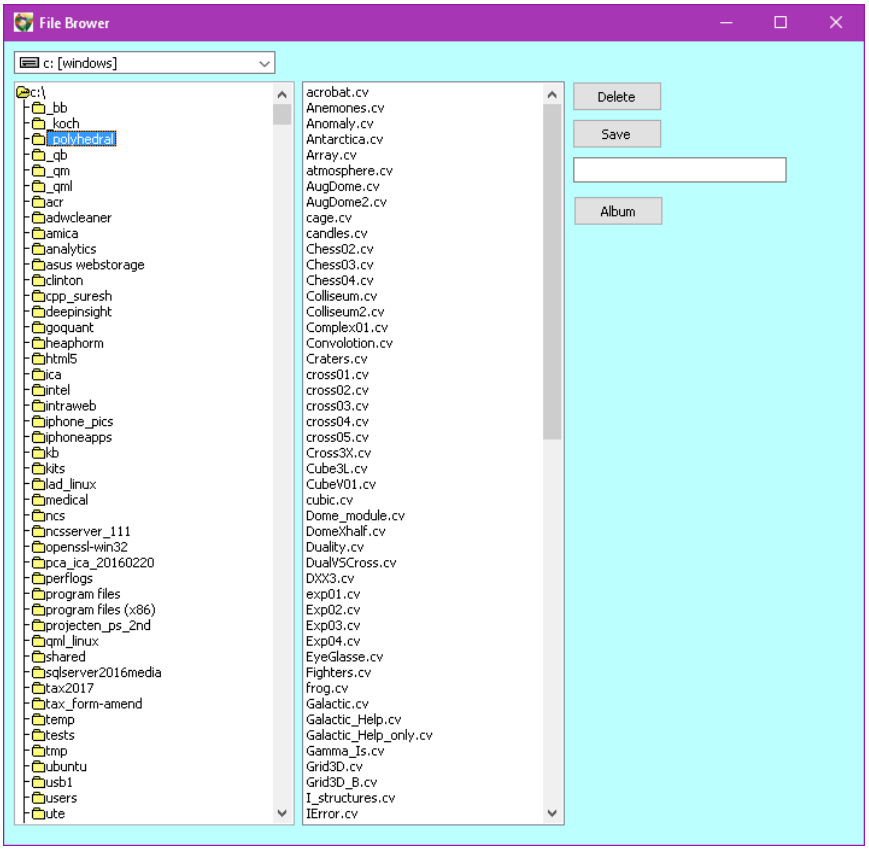
• Additional Features

File management is assured by the command in the main menu.

- Project
  - New
  - Open
  - Import
  - Save
  - Save PDF
  - Recording
    - Start
    - Append
    - Playback
    - Stop
  - Project Browser – opens a form for easy access to projects (see below)
- Image
  - Copy to clipboard
  - Save JPG
  - Background
    - Load – load a picture as background
    - Clear
- Operations
  - Control (see Section 11)
  - Random
  - Color (see Section 5)
- Help
  - Manual (This document)
  - Videos on YouTube
  - Pictures
  - About XColony
  - Register

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

Project browser is useful for managing a large number of projects.

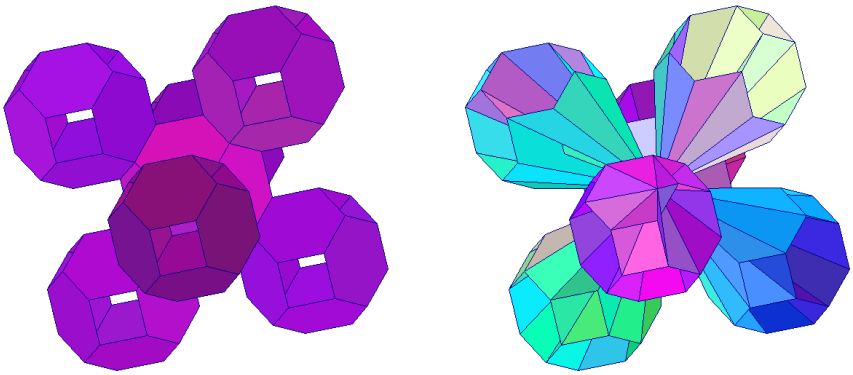


This form allows you to select the directory containing the project files. A simple click on one project file will open and visualize it.

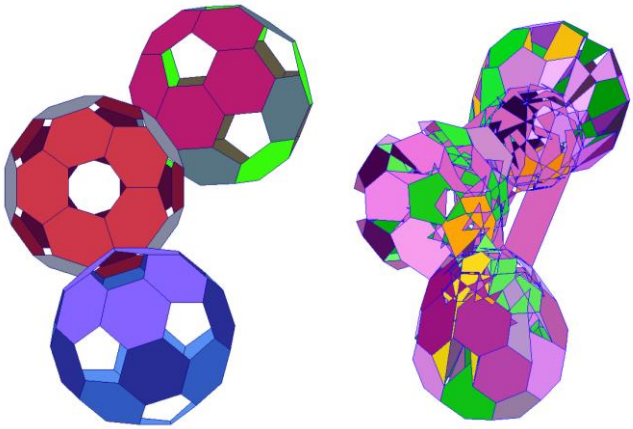
Album creates the file album.pdf file that contains the graphic index of all projects, one per page.

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

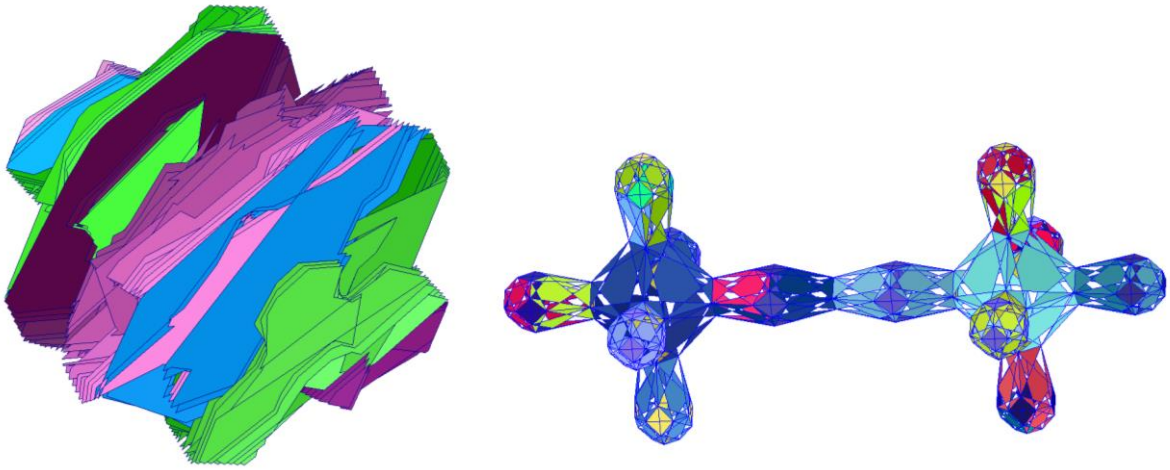
• Special Projects



PowerNabla(OTC) and its Star(1) transformation

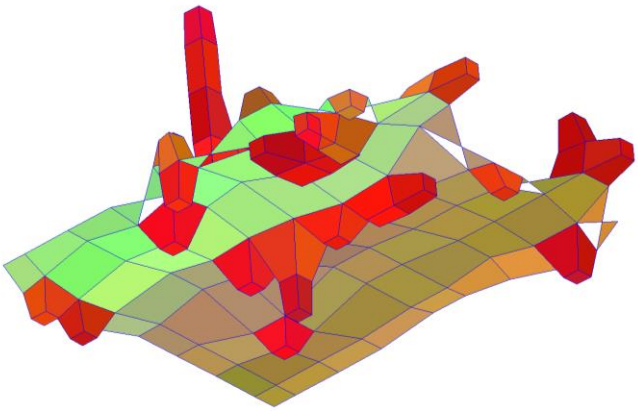


Three ITC modules Nabla connected and its Dual-Star-Dual transformation

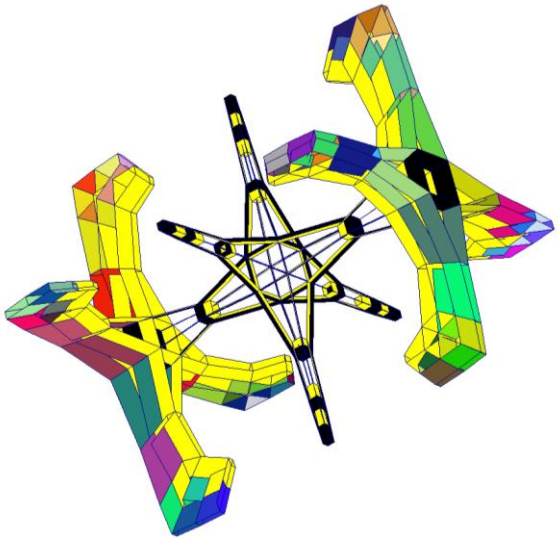


Slice and StarF Transformations of complex modules

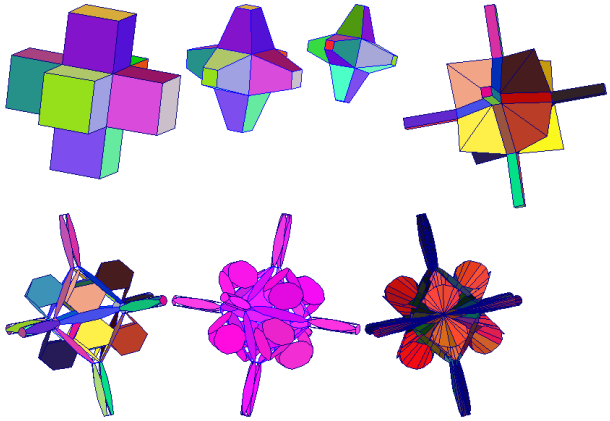
Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3



Transformations of a Chess grid augmented with cubes



Transformations of a 3D lattice



Graphic Index of a projects

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

- **Videos on Youtube**

1. Operations

https://youtu.be/yJKSzhbJKp4

2. Geometric Products

https://youtu.be/YeCnf6nk4p0

3. Spheres

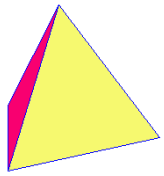
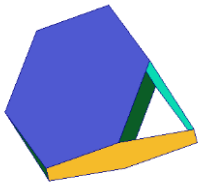
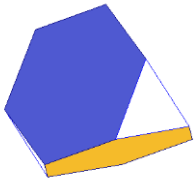
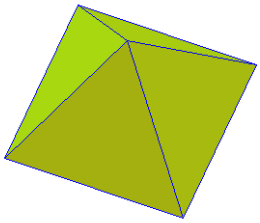
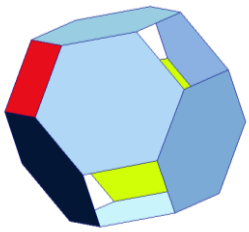
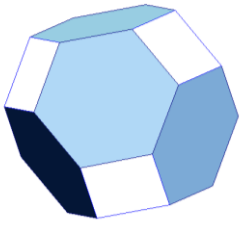
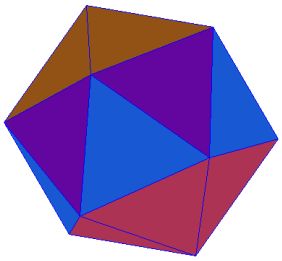
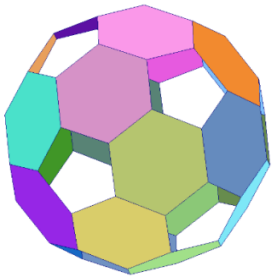
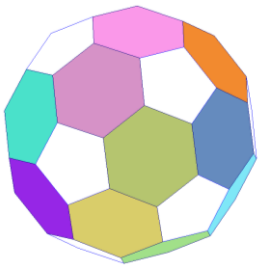
https://youtu.be/u7S-aDbusY4

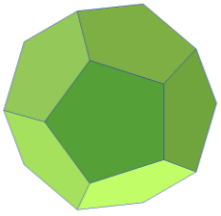
4. Fractal Pyramid

https://www.youtube.com/watch?v=bh-T_mH0pf4

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

Appendix A. List of Basic Modules

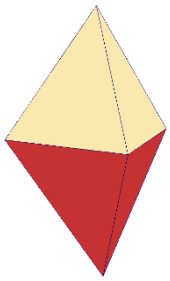
 T	 TT	 TTC
 O	 OT	 OTC
 I	 IT	 ITC

 C - Cube	 D - Dodecahedron

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

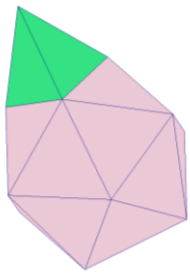
Appendix B. Polyhedral Computing Operations

The **Delta**, **Gamma** and **Nabla** operations described in the following tables.

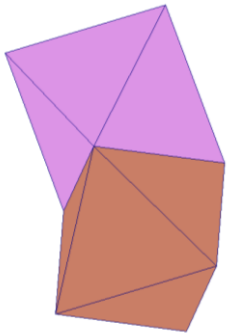


Delta(T,T)

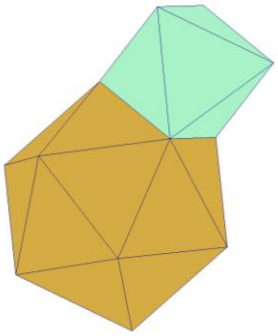
Delta(T,O)



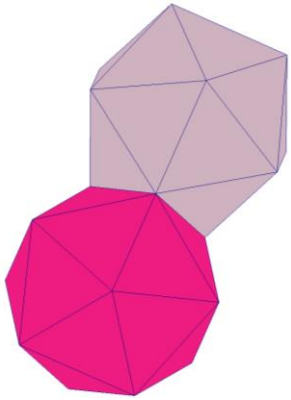
Delta(T,I)



Delta(O,O)

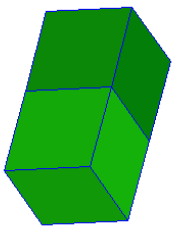


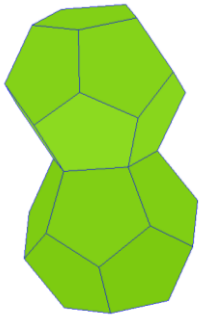
Delta(O,I)



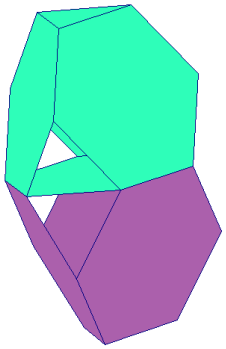
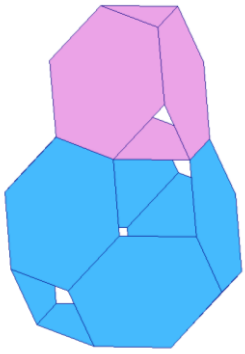
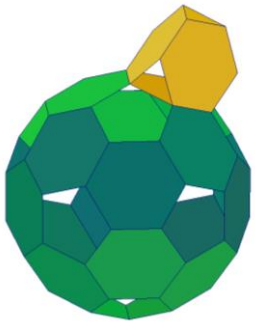
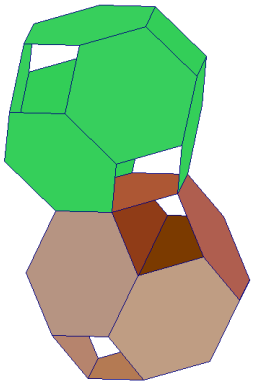
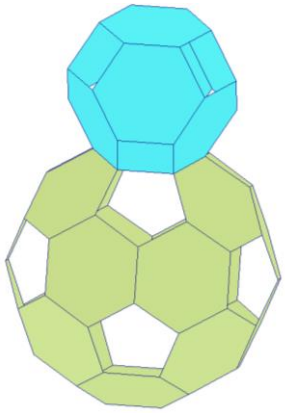
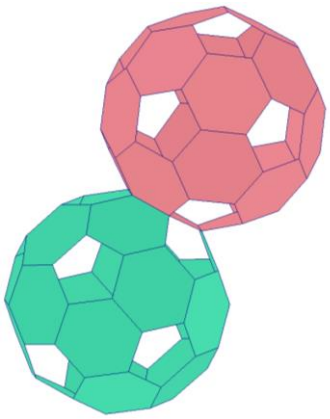
Delta(O,O)

Delta Operations (T, O, I, C, D)

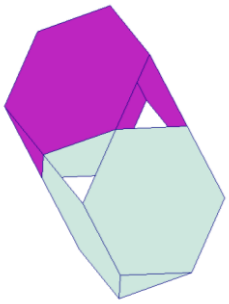
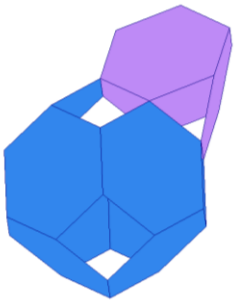
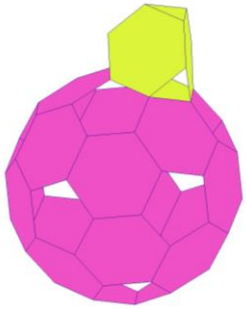
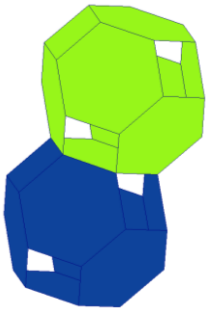
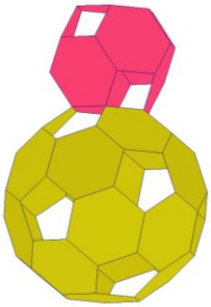
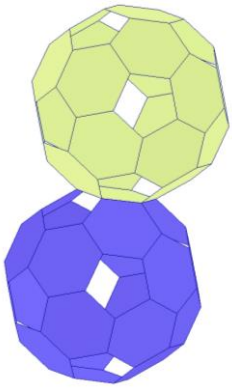


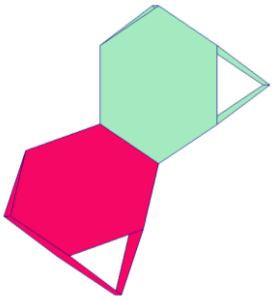
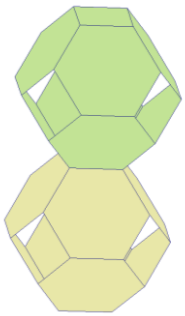
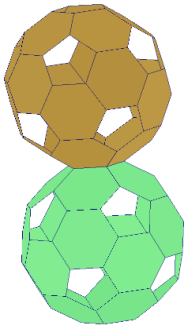


Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

Delta(C,C)		Delta(D,D)
 Delta(TT,TT)	 Delta(TT,OT)	 Delta(TT,IT)
	 Delta(OT,OT)	 Delta(OT,IT)
		 Delta(OT,IT)
Delta Operations (TT, OT, IT)		

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

 Gamma(TT,TT)	 Gamma(TT,OT)	 Gamma(TT,IT)
	 Gamma(OT,OT)	 Gamma(OT,IT)
		 Gamma(IT,IT)
Gamma Operations (TT, OT, IT)		

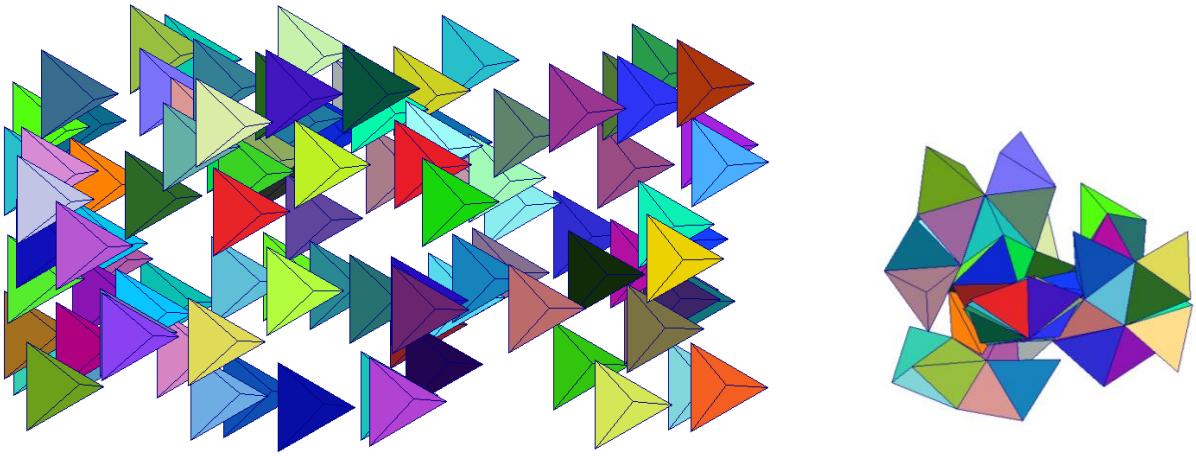
 Nabla(TTC,TTC)	 Nabla(OTC,OTC)	 Nabla(ITC,ITC)
Nabla Operations (TTC, OTC, ITC)		

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

Appendix C. Evolutionary Simulations

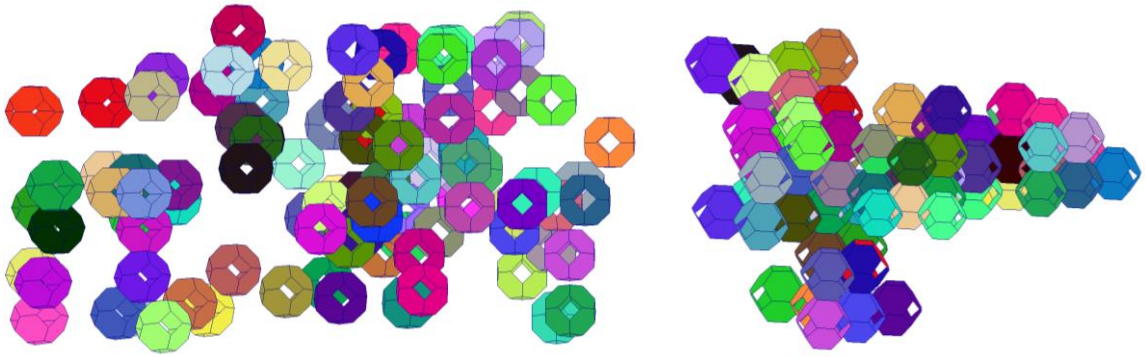
Selected random operations can be applied recursively via **Evolutionary** simulations.

Example 1. Apply Delta simulation to 100 T modules.
Generate a T module and 99 clones of it, distribute them randomly and click **Evolution.**



Evolutionary simulation with 100 T modules (initial and final states)

Example 2. Apply Nabla simulation to 100 OTC modules.
Generate 100 OTC modules, check **Nabla** operation only, distribute them randomly and click **Evolutionary**.

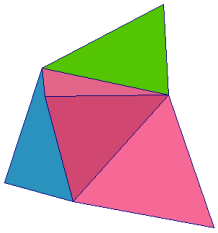
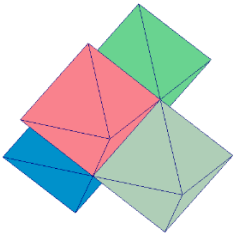
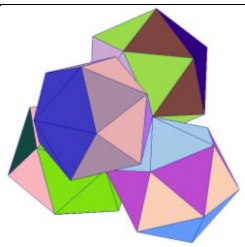
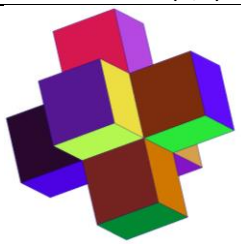
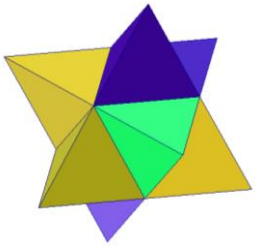
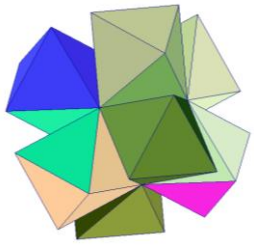
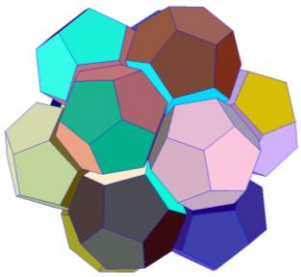
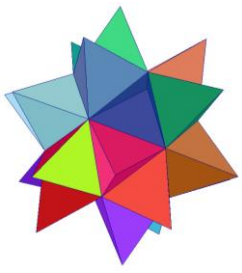
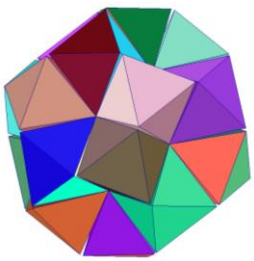


Evolutionary simulation with 100 OTC modules (initial and final states)

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

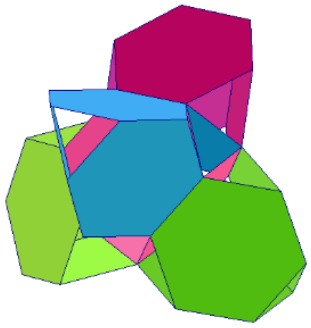
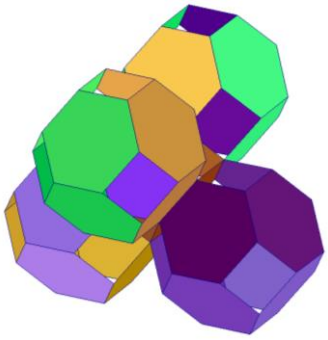
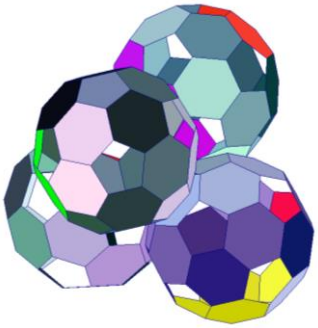
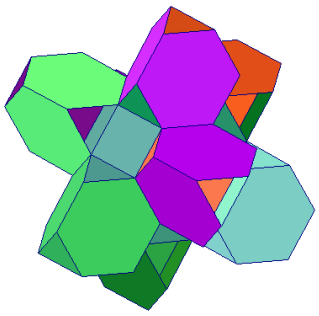
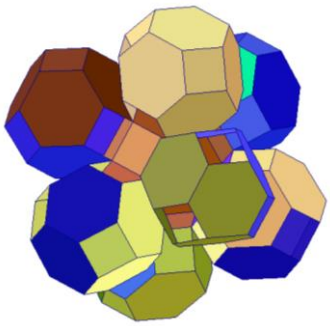
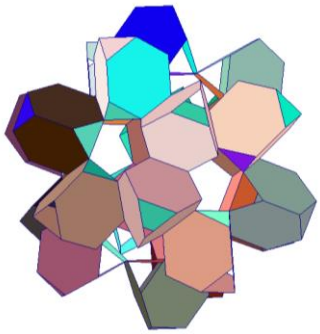
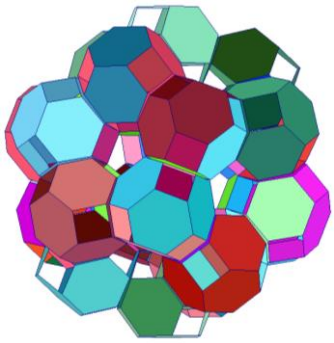
Appendix D. List of Cartesian Products

D1. Plain Type

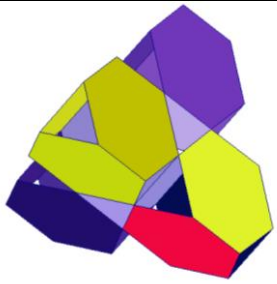
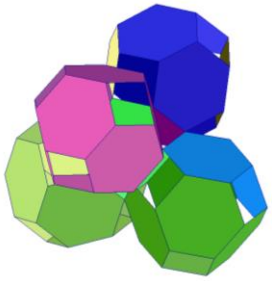
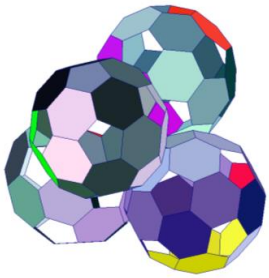
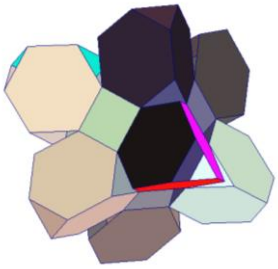
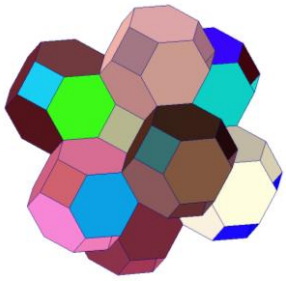
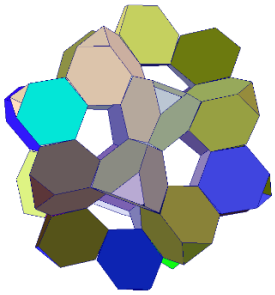
PowerDelta			
T	 PowerDelta(T,T)	 PowerDelta(T,O)	 PowerDelta(T,I)
C	 PowerDelta(C,C)		
O	 PowerDelta(O,T)	 PowerDelta(O,O)	
D	 PowerDelta(D,D)		
I	 PowerDelta(I,T)	 PowerDelta(I,O)	

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

D2. Truncated Type

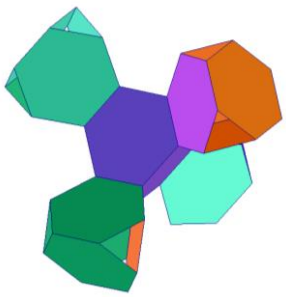
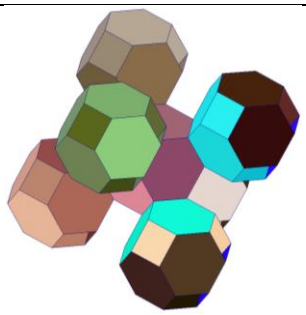
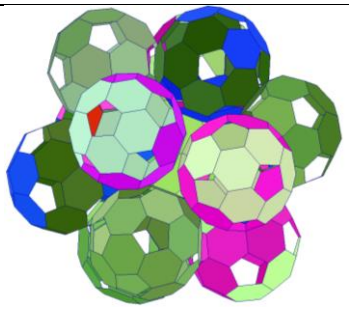
PowerDelta	TT	OT	IT
TT	 PowerDelta(TT,TT)	 PowerDelta(TT,OT)	 PowerDelta(TT,IT)
OT	 PowerDelta(OT,TT)	 PowerDelta(OT,OT)	
II	 PowerDelta(IT,TT)	 PowerDelta(IT,OT)	

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3

PowerGamma	TT	OT	IT
TT	 PowerGamma(TT,TT)	 PowerGamma (TT,OT)	 PowerGamma (TT,IT)
OT	 PowerGamma (OT,TT)	 PowerGamma (OT,OT)	
II	 PowerGamma (IT,TT)		

D3. Truncated with Cofacets Type

In addition to the products presented in Appendix D2, the objects with cofacets can be used in PowerNabla products, as in the following table.

PowerNabla	TTC	OTC	ITC
	 PowerGamma(TT)	 PowerGamma (OT)	 PowerGamma (IT)

Patent: PCT/US2013/069568, WO2015072960A2, WO2015072960A3