ShapeForge, an iOS app

ShapeForge is a 3D sketchpad, a way to create three dimensional shapes, map images onto them, share them with others, see them in three dimensions and even 3D print them. It uses a simple scripting language to create shapes. Some of the things that can be "drawn" are sphere, cube, torus, trefoil knot, Moebius strip, bow tie pasta, Cavatappi, etc. etc.

The starting figure is a square mesh of points. The script steps can scale, rotate, bend and twist the mesh. It is a bit like origami, but the actions are not folds but mathematical functions.

Each script and script step is created using an interface that lets the user choose the function and set parameters with sliders, buttons or by filling in text fields. Script editing is "point and click", you need not write any text. A slider in the main view allows the user to step through the script from the beginning mesh to the final shape, interpolating each step along the way.

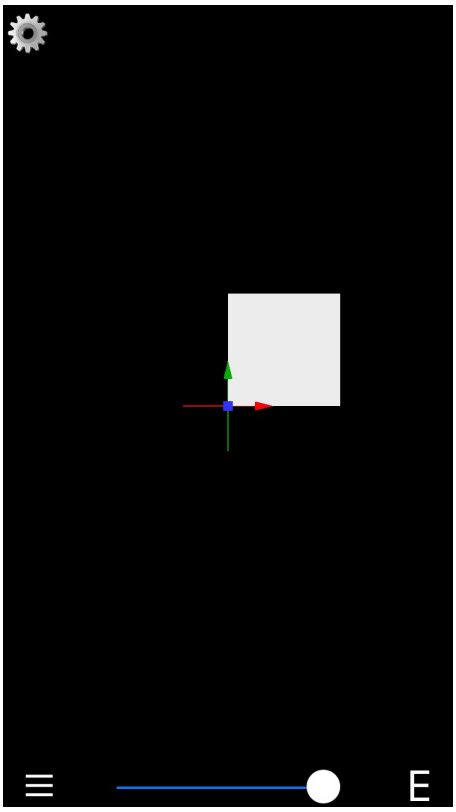
An image can be mapped onto the shape, one on the front and another on the back. The image can come from a library provided with the app, the user's photo album or directly from the camera. One can also present a live video view. The shape can be displayed as a simple surface or as points or lines of any color. The number of points in the shape can be varied.

Swipe or pinch the screen to enlarge, shrink, move or rotate the shapes. Turn the device to the left to see a pair of images in stereo. A virtual reality viewer like Google Cardboard or Samsung Gear will help see the stereo effect. Turn the device to the right to see an anaglyph (red-green) stereo view. You will need red-green glasses to see the effect.

Shapes, each comprising a mesh, a script and an optional image can be emailed for viewing and editing on another device where this app is installed.

An STL file can be created and emailed for 3D printing.

Privacy: Shapeforge does not store or share any personal information.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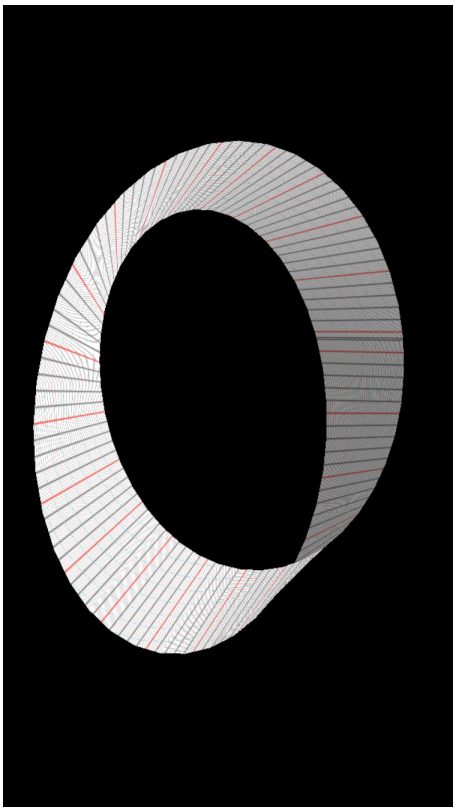

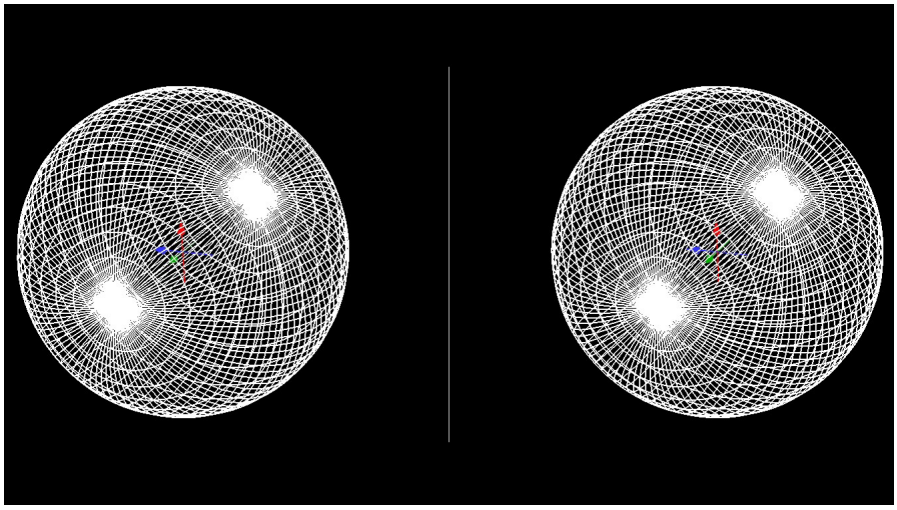

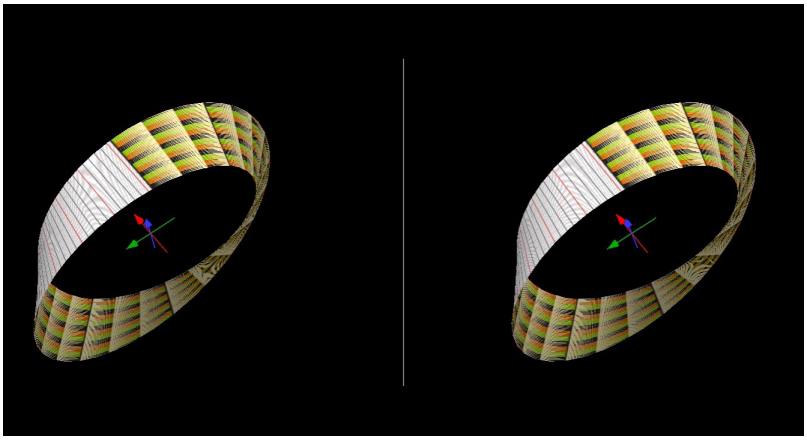

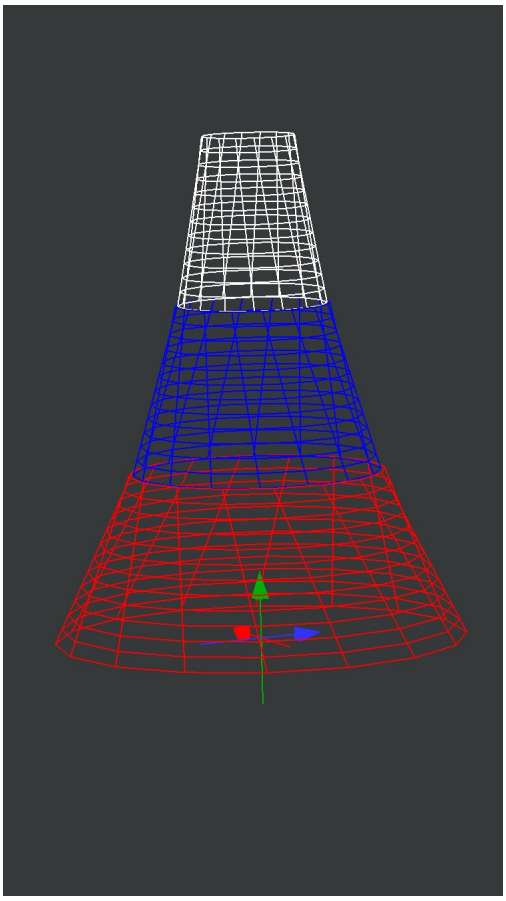

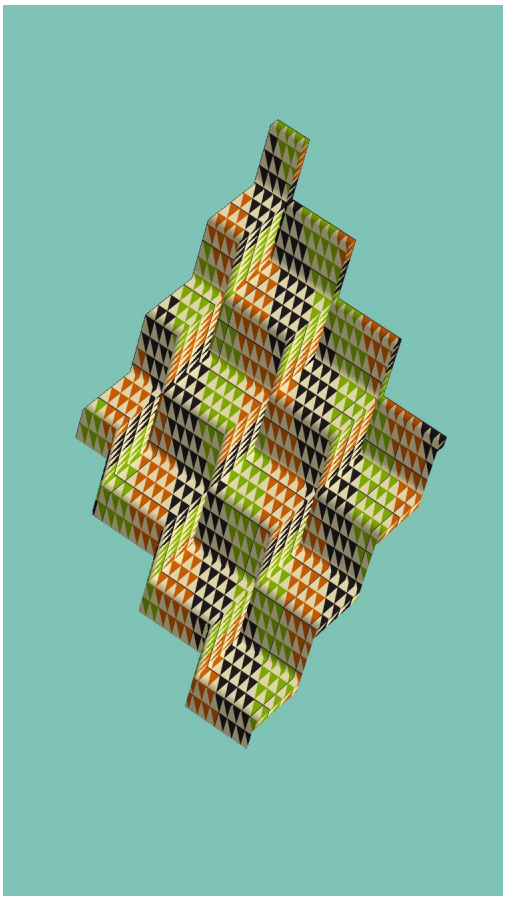

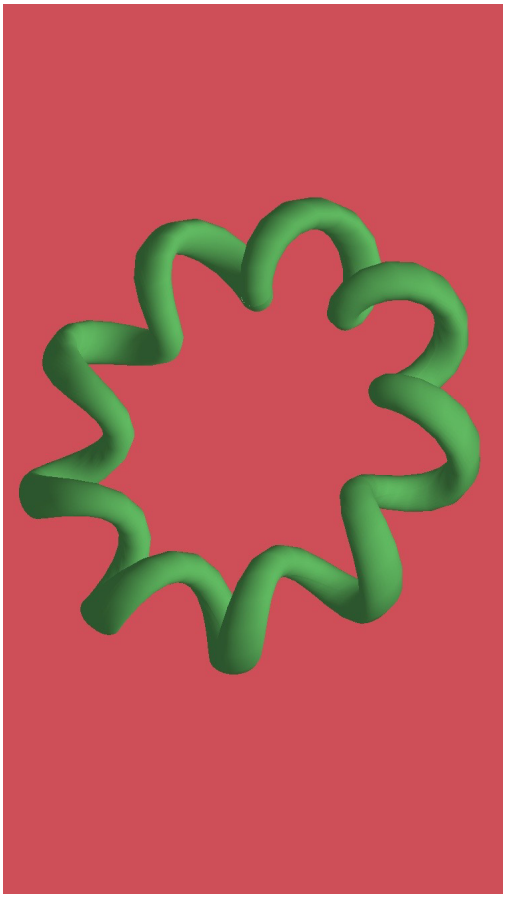

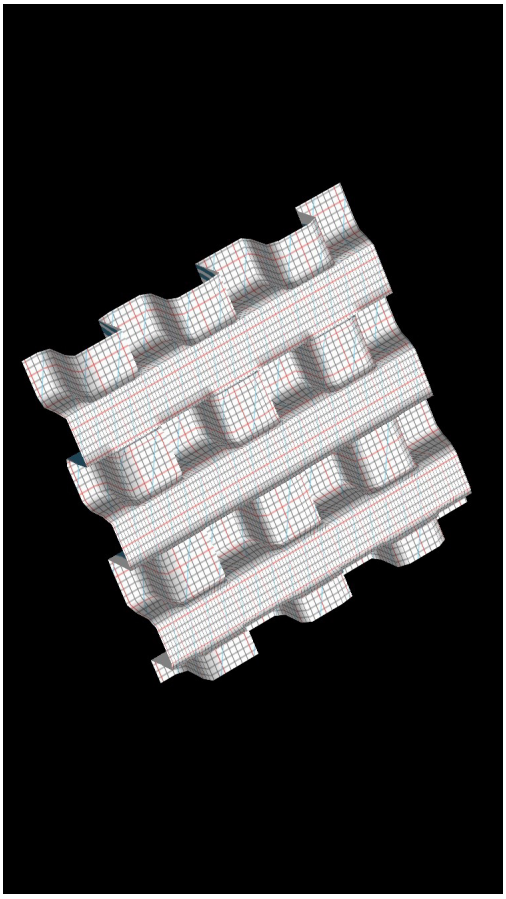

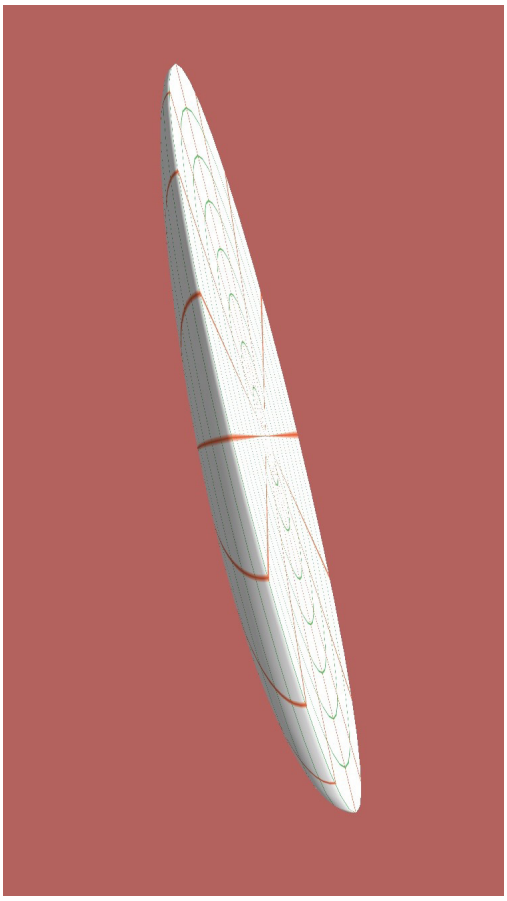

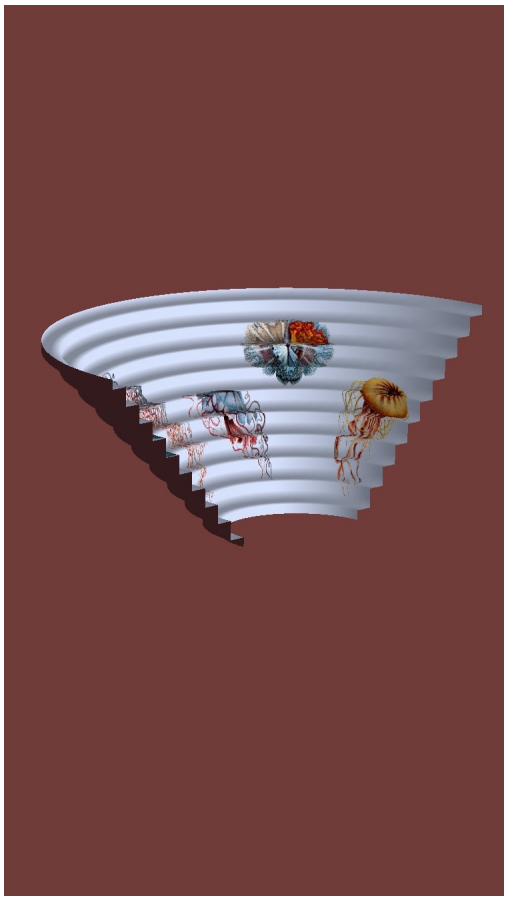

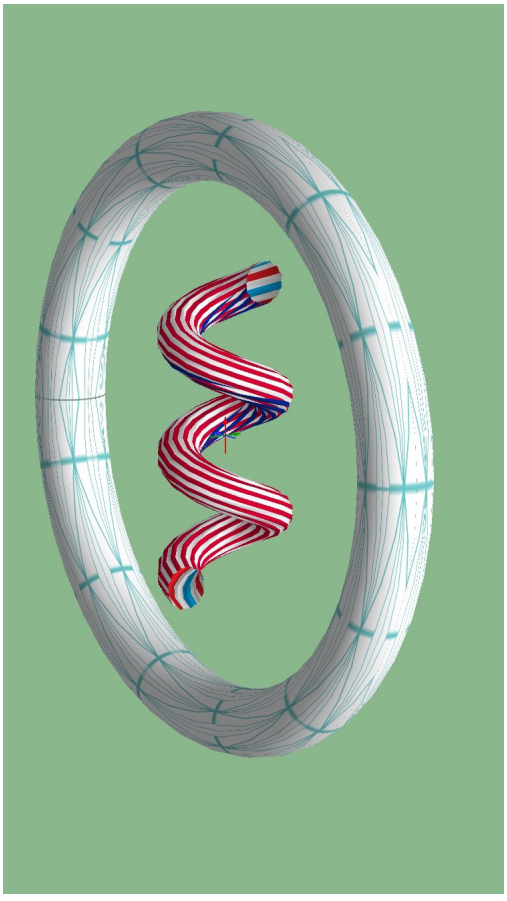

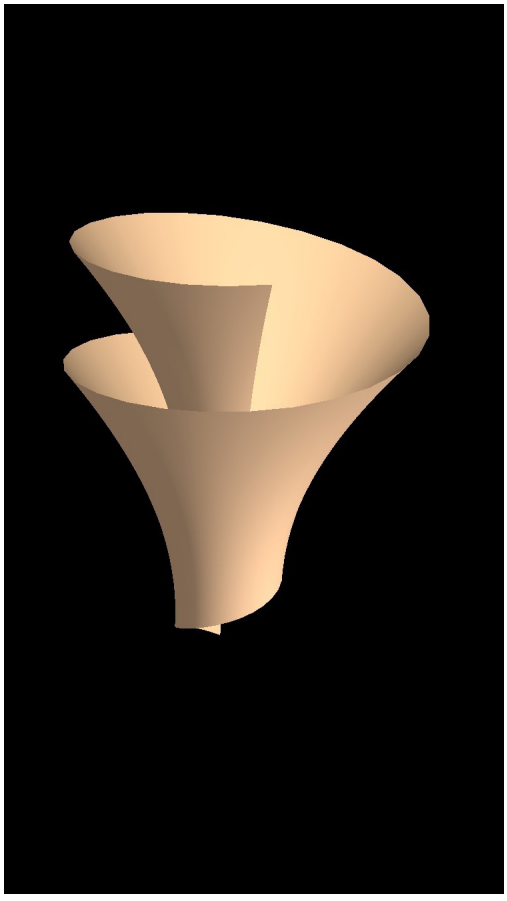

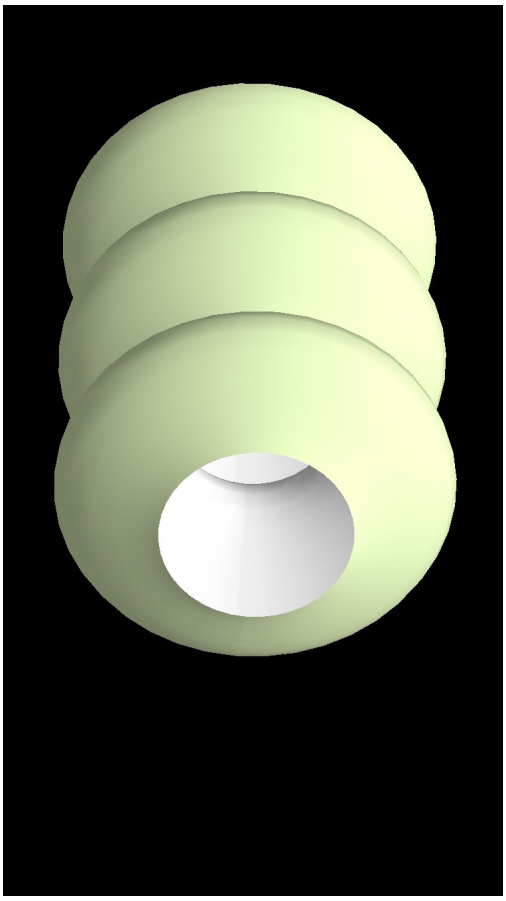

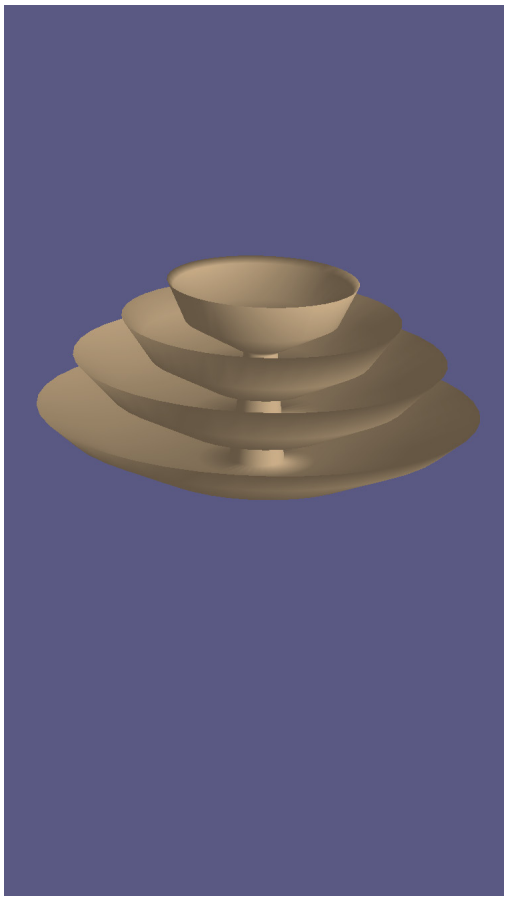

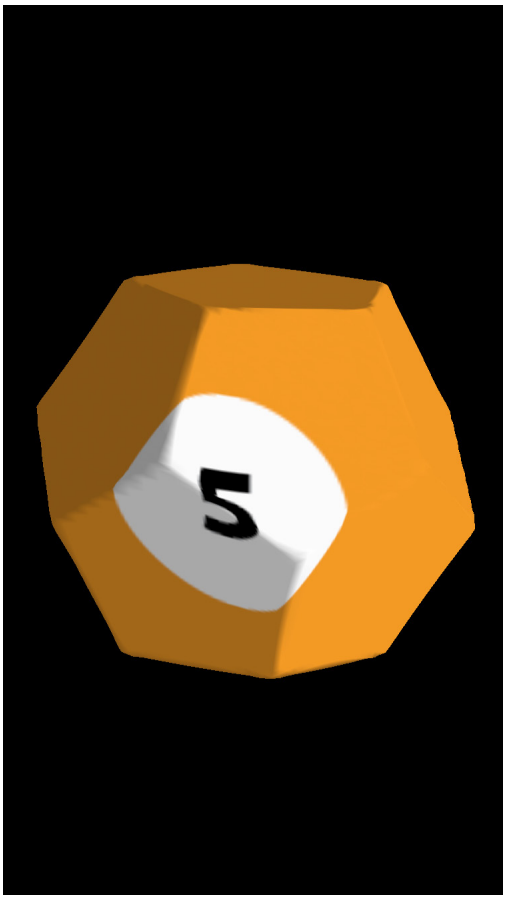
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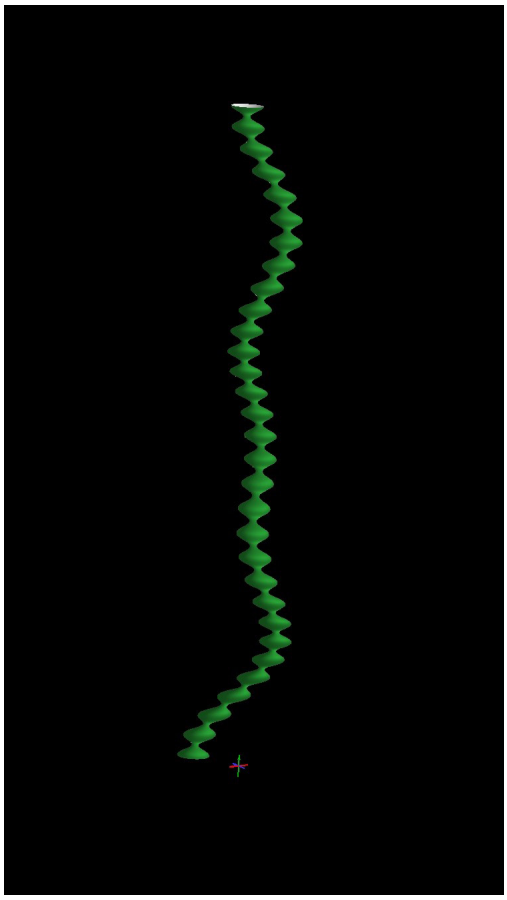
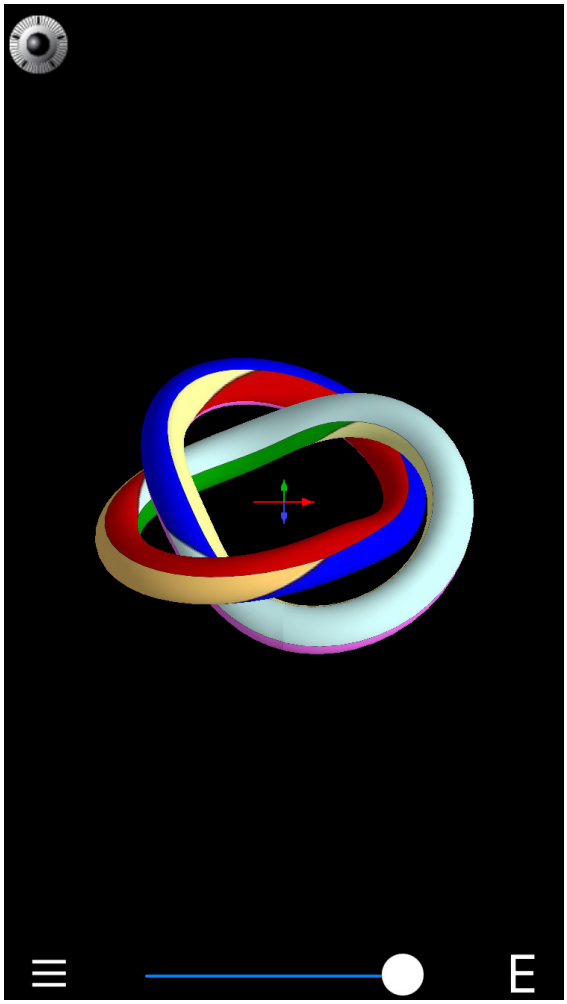


The Main Screen

Swipe to rotate the shapes. Pinch to change size and spin. Double tap to hide the controls.

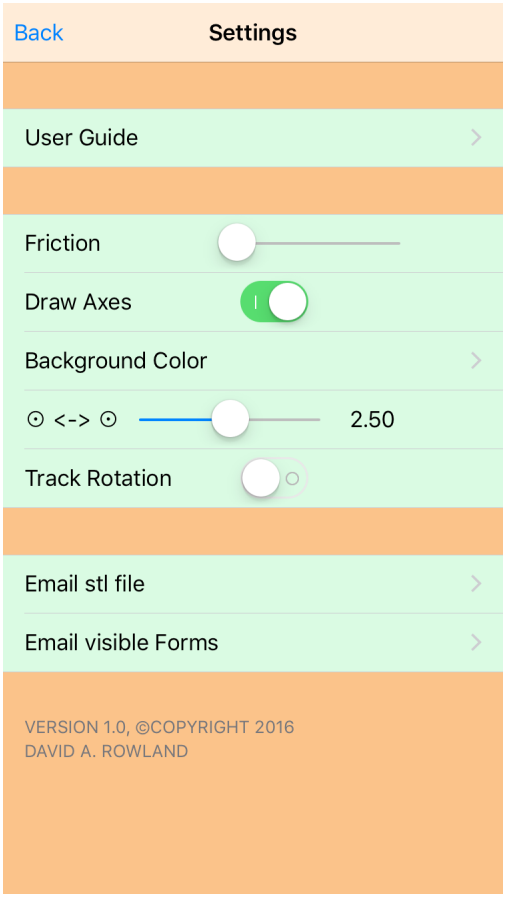


Go to the Settings panel

Show the available shapes

Interpolate the script from beginning to end

Edit a shape



Settings

Friction controls the response to a swipe. At zero the shape will rotate permanently. Above zero it will decrease its speed and eventually stop.

Draw Axes controls the display of the X,Y and Z axes in the center of the screen.

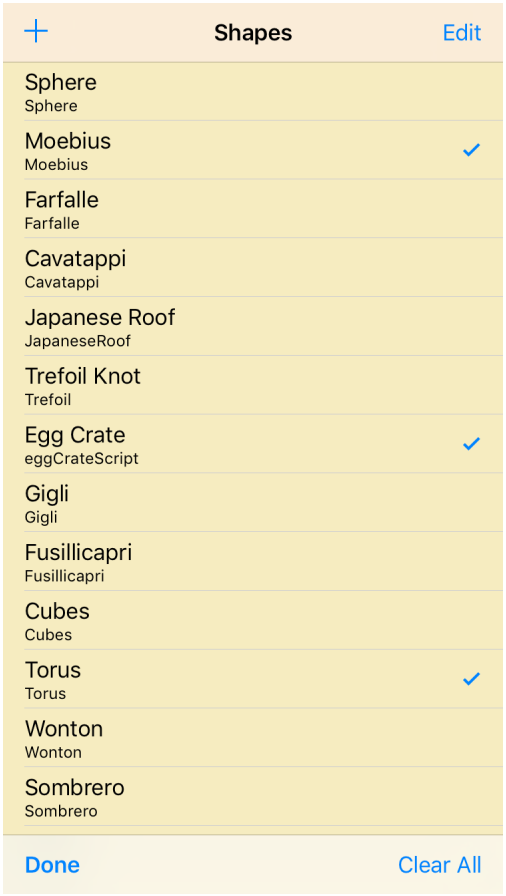
Background Color lets you choose the background color. It begins as black.

o <-> o controls the spacing of the images in a stereo view. Units in inches.

Track Rotation uses the device's gyro and accelerometer to adjust the view according to the attitude of the device. As you move the device around, the shape will behave as though it was fixed in space. You can "walk around" and see all sides.

Email stl file creates an stl file for each visible shape and sends them by email. It is plain text. Printing software like Cura can read it and drive a 3D printer.

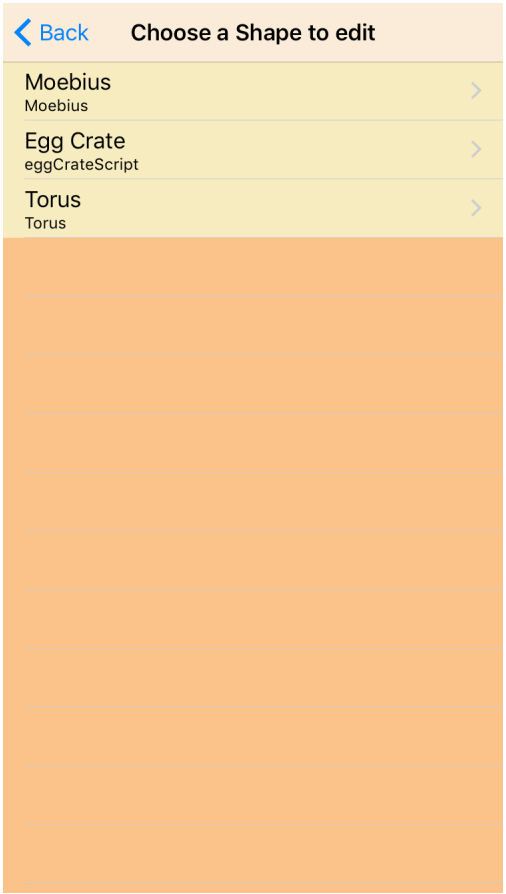
Email visible shapes sends a file containing descriptions of the visible shapes, including their images. When another device receives the mail and has ShapeForge on it, the mail program can send the file to ShapeForge for viewing and editing.



Display List

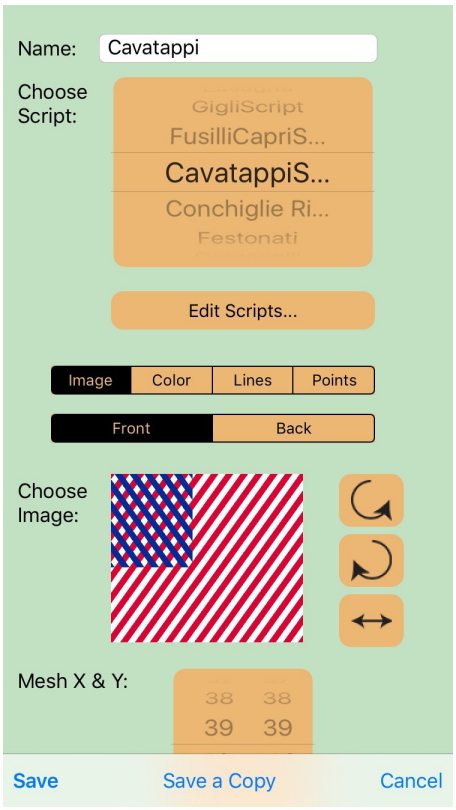
The display list shows the shapes in the library of the app. A check mark indicates whether a shape will be shown on the screen. You may choose any number of shapes to be shown simultaneously.

You may also edit the list to change the order of shapes, delete them and create new shapes. A new shape is given the name “new” and a null script.



Edit List

If only one shape is visible the “E” will take you straight to the shape editor. If more than one is displayed it will go to this list and allow you to choose which will be edited.



Shape editor

On small screens this is a scrollable field, allowing you to see the rest of the mesh picker.

Name: Enter the name for the shape.

Choose Script: Use this picker to select one of the available scipts.

Edit Script: This presents a list of scripts from which you can choose one to be edited. The currently chosen script will be highlighted in the list. You will be able to create new scripts in that list.

Image-Color-Lines-Points: A shape can display two images, one on each side. Or you can choose to color each side. The shape can be displayed as grid lines in X or Y or both and as points of the mesh.

Front-Back: Choose which side the image will be applied to. Lines and Points do not allow a choice of side.

Choose Image: The image can come from the library provided with the app, from the photo library on the device, from the camera on the device (front or back) or as an active video from the front or back camera. The buttons to the right let you choose the orientation of the image.

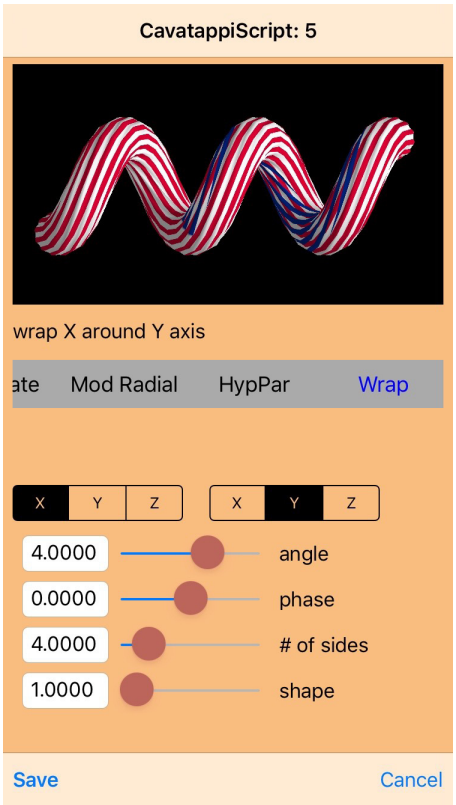
Mesh X&Y: The shape is constructed starting with a rectangular mesh of points. You choose how large the mesh is in the X and Y directions. The default is 40 by 40. More points means a smoother rendition but longer time to build the shape.

If you press Cancel your changes will be discarded.

Script Editor

The script editor shows the script name and the steps with their parameters. Tap the "+" to add a step to the script (it will be a No-op). Use the Edit feature to change the order of steps or remove them.

If you press Cancel your changes will be discarded.



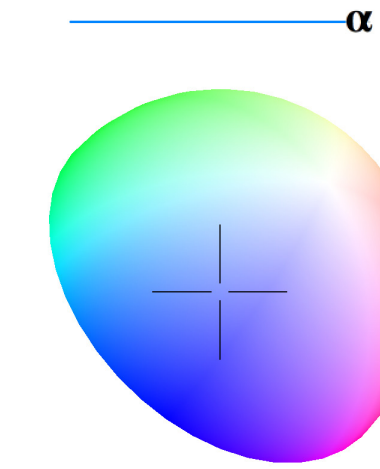
Script Step Editor

The script name and step number are shown at the top. The view shows the shape. If you are editing the current script as shown in the shape editor your changes will be seen in this view. You can edit scripts other than the current script, but if they are not used by this shape the changes will not be visible.

The commands used in script steps are shown in the gray panel below the image. Swipe left and right to see the full set. Tap one to choose it. When you choose one, the controls below will change to show the options for that command.

Each group of edit box, slider and title lets you set the named parameter for that step. The slider will set the number, but if you need finer control tap the edit box. A keyboard will appear and you can set the value precisely. Depending on the parameter the slider's behavior will be linear, non-linear or exponential.

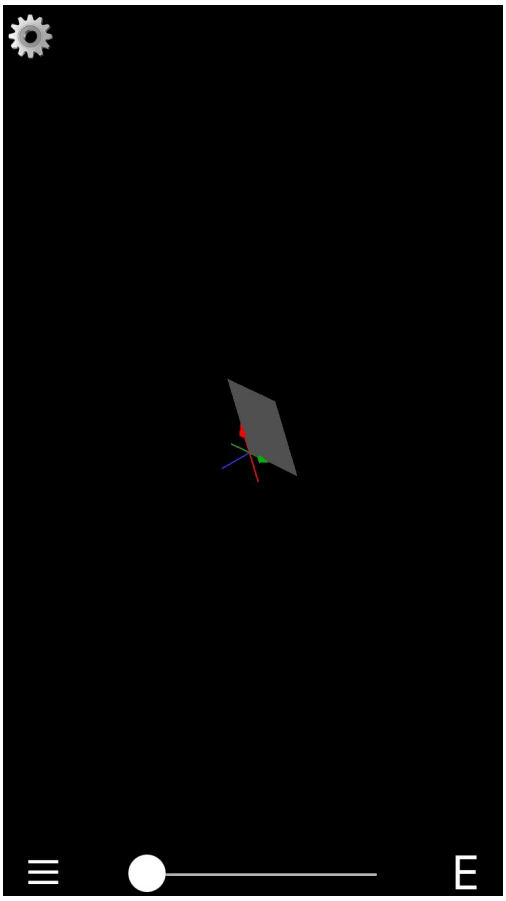
If you press Cancel your changes will be discarded.

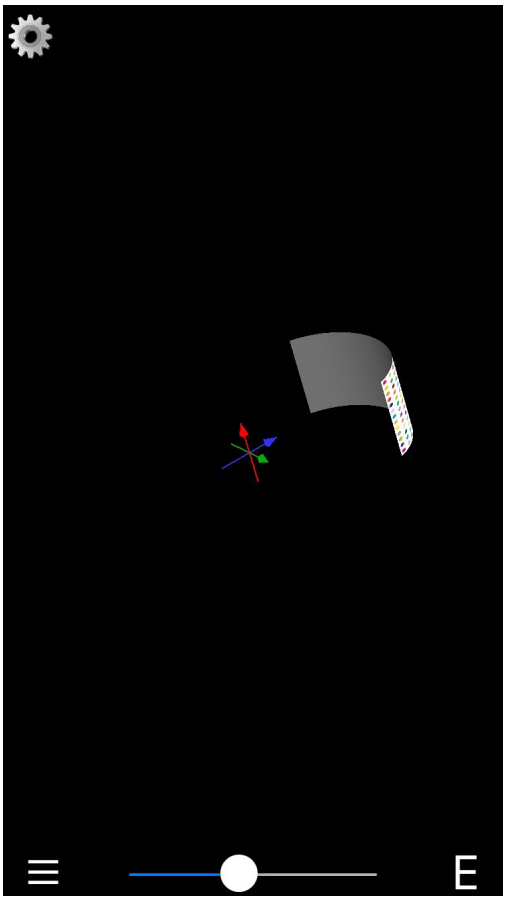


Color Picker

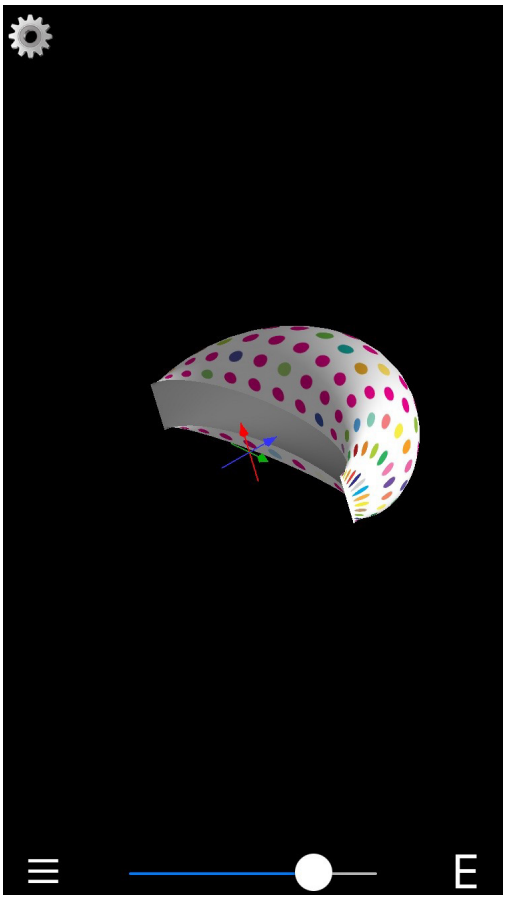
The color picker is used to set the background color and to choose a color for either side of the mesh. Colors are modeled as a half sphere which rotates by swiping the screen. Overall brightness is set by the slider at the botto. The check confirms the choice, the X rejects it.

When setting the color for a shape, there will be a slider to set the alpha, or transparency. Transparent shapes will be seen as transparent only when they are drawn after the shapes behind them are drawn. Shapes are drawn in the order shown in the Display Liat. Make transparent shapes the last to be drawn by putting them below non-transparent shapes in the Display List.

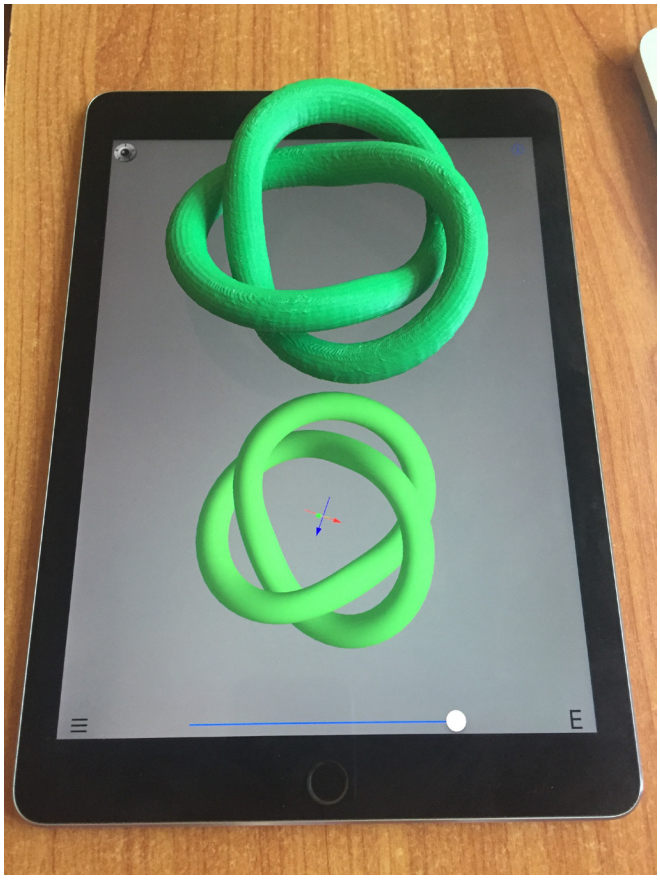




These screen shots show how the script builds the mesh into a sphere. The steps are interpolated by the slider at the bottom of the screen.



The app can output an STL file (text mode) for use in 3D printing. Cura, among other apps, can read the output, scale it and prepare it for printing.



The scripting steps
Most steps allow you to choose the axis or axes along which it has effect. Each is described with a simplified formula showing its effect along or around the x axis. The app contains scripts that show these steps in use.

No-op
The No-op does nothing. When a new step is created it is given the No-op command.

Scale
Scale expands or shrinks the mesh along the chosen axis. The magnitude ranges from -12.0 to +12.0.

```
x = x * m
```

Offset
Offset moves the mesh along the chosen axis. The magnitude ranges from -12.0 to +12.0.

```
x = x + m
```

Rotate
Rotate turns the mesh around the chosen axis. A unit of 1.0 is one quarter turn (90 degrees). The angle ranges from -2.0 to 2.0, i.e. one full rotation. The magnitude amplifies the effect.

```
newAngle = (position + angle) * mag
```

Divide
Divide partitions the mesh along the chosen axis. Mesh points that are less than "offset" along that axis are affected by the "mag.-" value. Those that are greater than "offset" are affected by "mag.+".

```
d = x - offset
if (d > 0)
   newx = offset + d * mag+
else
   newx = offset - d * mag-
x = newx
```

Twist
Twist warps the mesh along the chosen axis. Imagine twisting a ladder into a helix.

```
float angle = mag
x = x
y = y * cos(angle) - z * sin(angle)
z = y * sin(angle) + z * cos(angle))
```

The subfunctions (see below) allow you to shape the twist. "Linear" is like twisting a ladder into a helix. "Cosine" makes the twist go in alternating directions. "wavelength" defines how rapidly the alternation happens. It varies from 0.01 to 10.0. "phase" affects the phase of the cosine function. It ranges from -2.0 to 2.0. "magnitude" defines how great the twist is. It ranges from -12.0 to 12.0

Spiral
Spiral warps the mesh around the axis. Twist varies the warp by how far along the axis the point is. Spiral varies the warp depending on the distance from the axis.

```
float theta = atan2(y, z);
float r = sqrt(z*z + y*y);
```

```
float thetaPrime = theta - r * pi/2.0;
x = x
y = r * sin(thetaPrime),
z = r * cos(thetaPrime)
```

Ripple

Example, ripple in Y by a function of X. The function is one of the available subfunctions, q.v.

```
x = x;
y = subfn(x);
z = z;
```

Rip Radial

Example, ripple radially around the z axis.

```
r = sqrt(x*x + y*y)
x = x;
y = y;
z = subfn (r)
```

Modulate

Modulate is very similar to Ripple.

Example, modulate in Y by a function of X. The function is one of the available subfunctions, q.v.

```
x = x;
y = y * subfn(x);
z = z;
```

Mod Radial

Similar to Ripple Radially

Example, modulate radially around the z axis.

```
r = sqrt(x*x + y*y)
x =x;
y = y;
z = z * subfn (r)
```

HypPar

Warps the space so that lines perpendicular to the chosen axis are turned but remain straight and remain perpendicular, lines parallel to the axis are turned but remain straight and other lines become curved.

Example: Shukhov, Saddle

Wrap

Wrap bends the shape around a chosen axis. It treats a second axis as defining the radius and the third as defining the angle. In addition it uses a simplified version of the Superformula proposed by Johan Gielis to shape the result. It can produce a circular shape or one with between 3 and 12 sides. Example: SphereScript

Do Script

Calls the script, chosen from a script picker, and continues with the next step. If a script calls itself directly or indirectly, it will cause an unbounded recursion and a crash.

Subfunctions

To expand the possibilities there are subfunctions that can give different shapes to some of the main functions. The subfunctions are: linear, cosine, bell (gaussian), square and step. They can be used with twist, spiral, ripple and modulate.

A linear ripple is a shear. A cosine ripple is a wave. The square subfunction distributes the mesh points over a square wave, which can be altered from a sawtooth to a square to an oversquare shape.

Tags: 3D printing, computational geometry, virtual reality, 3D sketch, iOS, OpenGL, origami

References:

"Pasta by Design" by George Legendre, Thames & Hudson, 2011.
"Encyclopedia of Pasta" by Oretta Zanini de Vita, Univ. of California Press, 2009.
"Morphing - A Guide to Mathematical Transformations for Architects and Engineers" by Joseph Choma, Laurence King Publishing Ltd. London, 2015

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