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ShapeToolbox: Creating 3D models for vision research

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3D models in vision research

3D models are used as stimuli in vision research in, e.g.:

- Shape perception
- Material perception

Advanced software packages exist for model creation, but they

- Might not have scripting capabilities
- Might not provide fine parametric control over shape
- Might not be free

`ShapeToolbox` for `Matlab` & `GNU Octave`

- Provides a handful of simple "base shapes" that can be perturbed by adding noise, bumps, dents, sinusoids, etc.
- Save as Wavefront obj-files
- Free and open source

`github.com/saarela/ShapeToolbox`

Basic usage

- Create a sphere with default sinusoidal modulation, store the model in structure `m`, and view it:

```
m = objMakeSine('sphere')
objView(m)
```

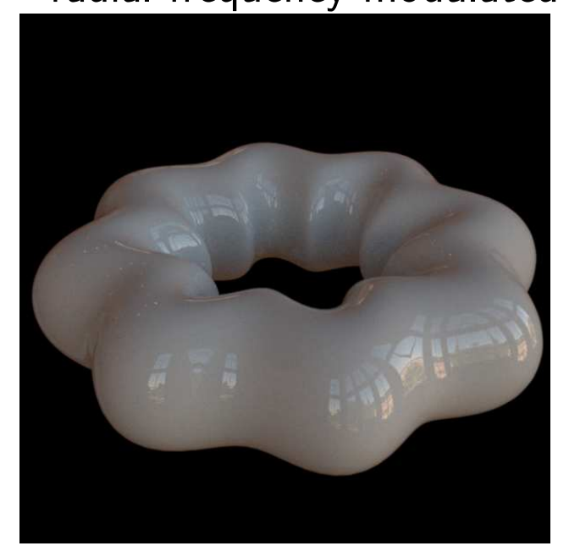
- A torus with custom noisy modulation, save in a file `torus.obj`:

```
m = objMakeNoise('torus',[4 1 60 10 .15],'torus')
```

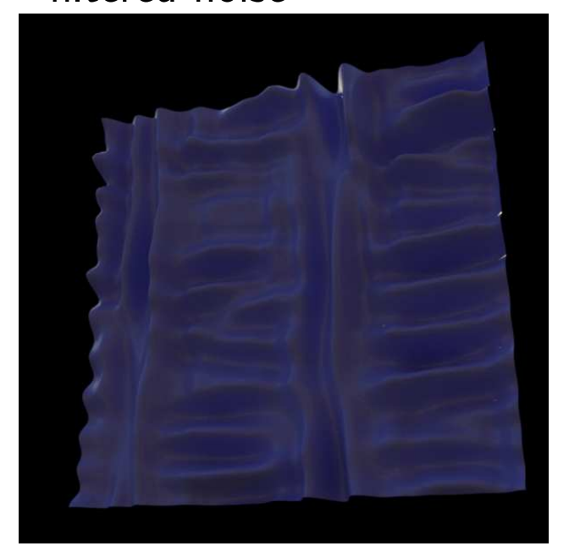
- Several options available for customizing the model, given as name-value pairs to `objMake*`-functions

Example shapes and perturbations

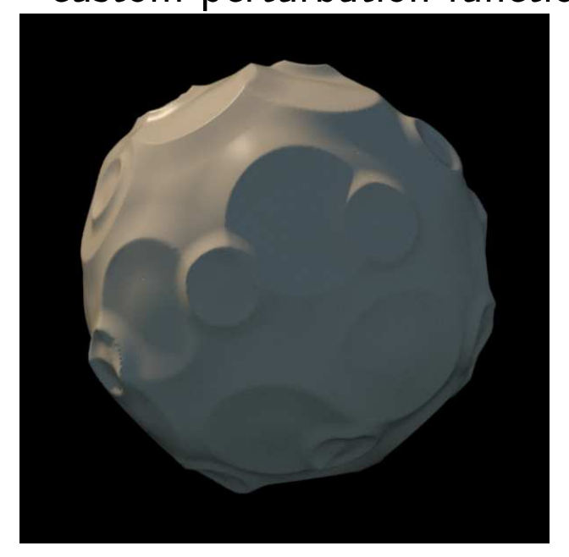
`objMakePlain('torus',...)`
- radial frequency modulated



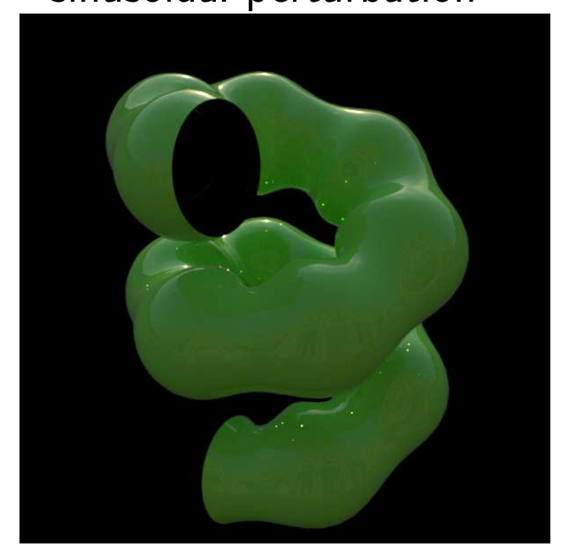
`objMakeNoise('plane',...)`
- filtered noise



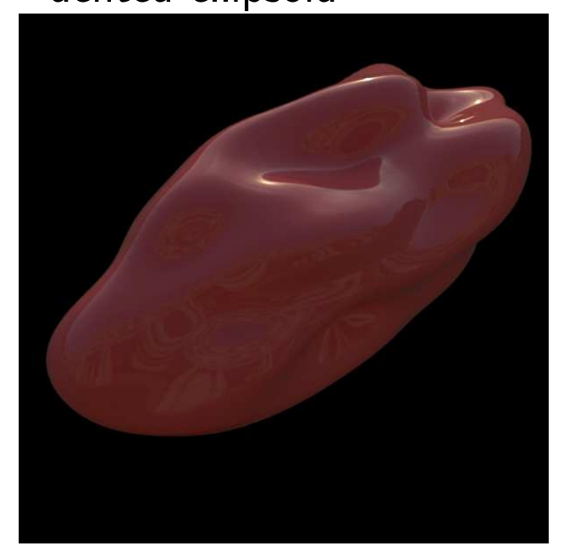
`objMakeCustom('sphere',...)`
- custom perturbation function



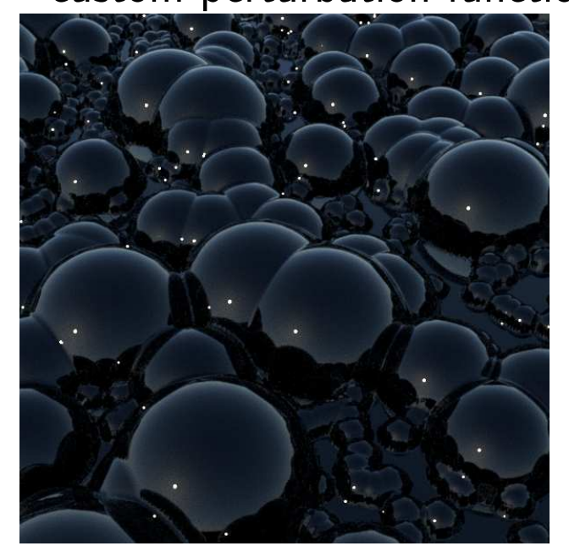
`objMakeSine('worm',...)`
- sinusoidal perturbation



`objMakeBump('ellipsoid',...)`
- dented ellipsoid



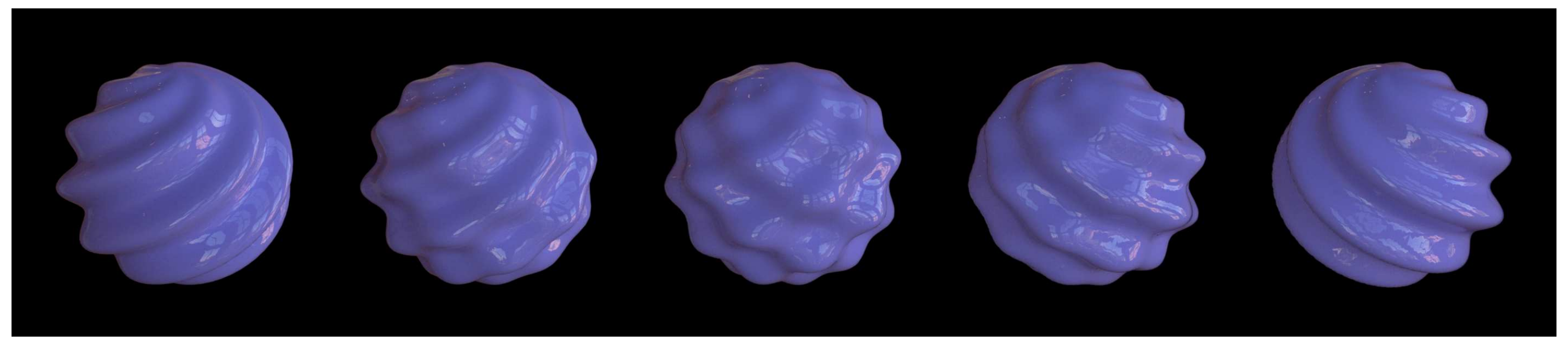
`objMakeCustom('plane',...)`
- custom perturbation function



Parametric series

- Change perturbation amplitude to create a series of shapes:

```
a = 0:.025:.1;
for ii = 1:length(a)
  m{ii} = objMakeSine('sphere',...
                      [12 -60 0 a(ii); 12 60 0 .1-a(ii)],...
                      [2 90 90 1]);
end
```



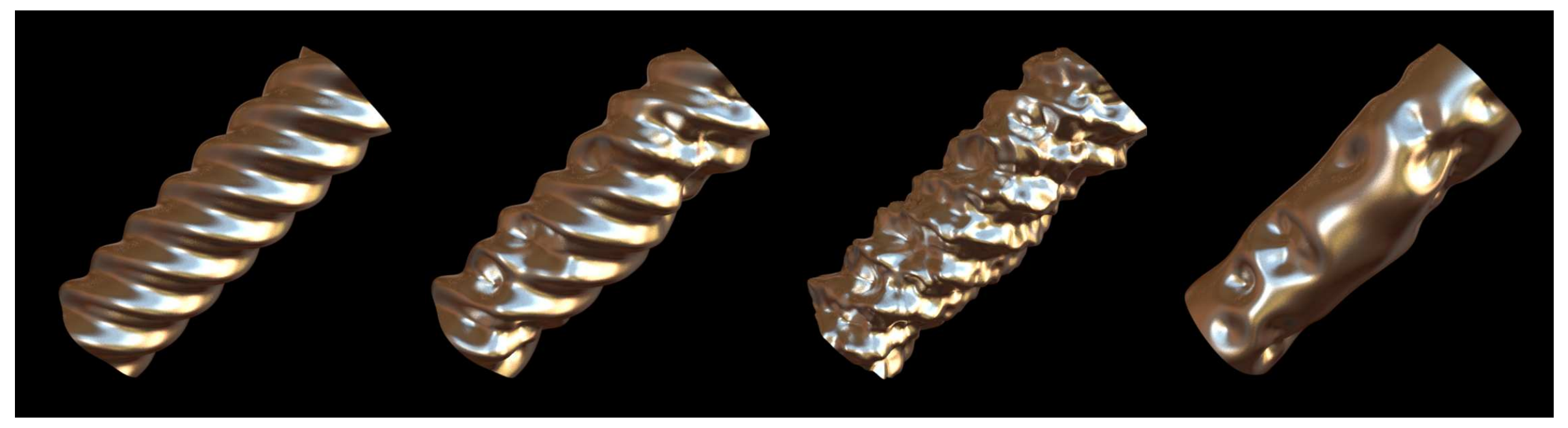
Chaining perturbations

- Combine several types of perturbation in a single model
- Model structure given as input to another `objMake*`-function:

```
m = objMakeSine('cylinder',[8 60 0 .1]);        % sine, left panel
m = objMakeBump(m,[50 pi/8 .1; 50 pi/16 -.2]);  % add bumps & dents
m = objMakeNoise(m,[16 1 0 Inf .1]);            % add noise
```

- "Turn off" some of the perturbations using `objSet`:

```
m = objSet(m,'use_perturbation',[0 1 0]); % sine & noise off, right panel
```

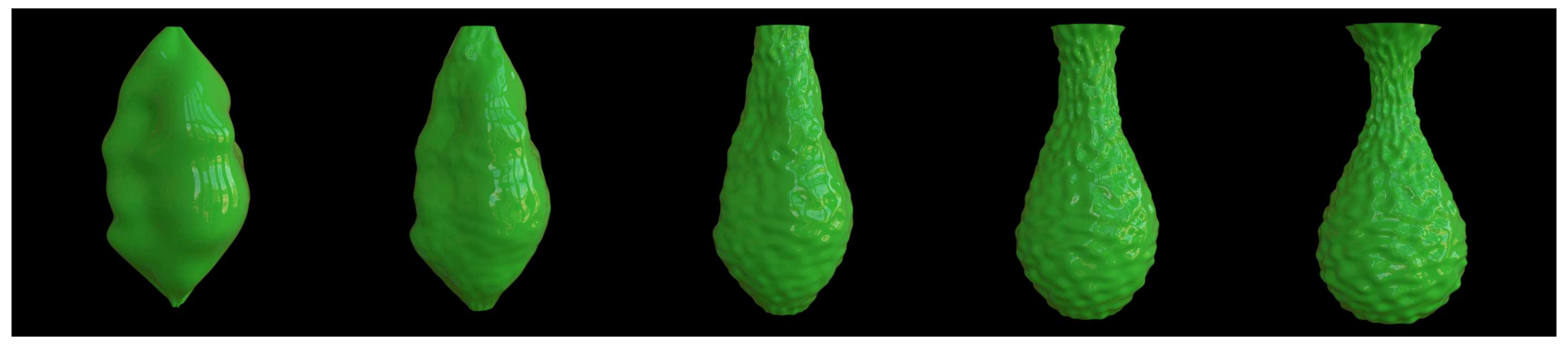


Blending

- Blend two shapes in arbitrary proportions:

```
m1 = objMakeBump('revolution',...)
m2 = objMakeNoise('revolution',...)
w = [0 .25 .5 .75 1];
```

```
for ii = 1:length(w)
  m{ii} = objBlend(m1,m2,w(ii))
end
```



More complex shapes

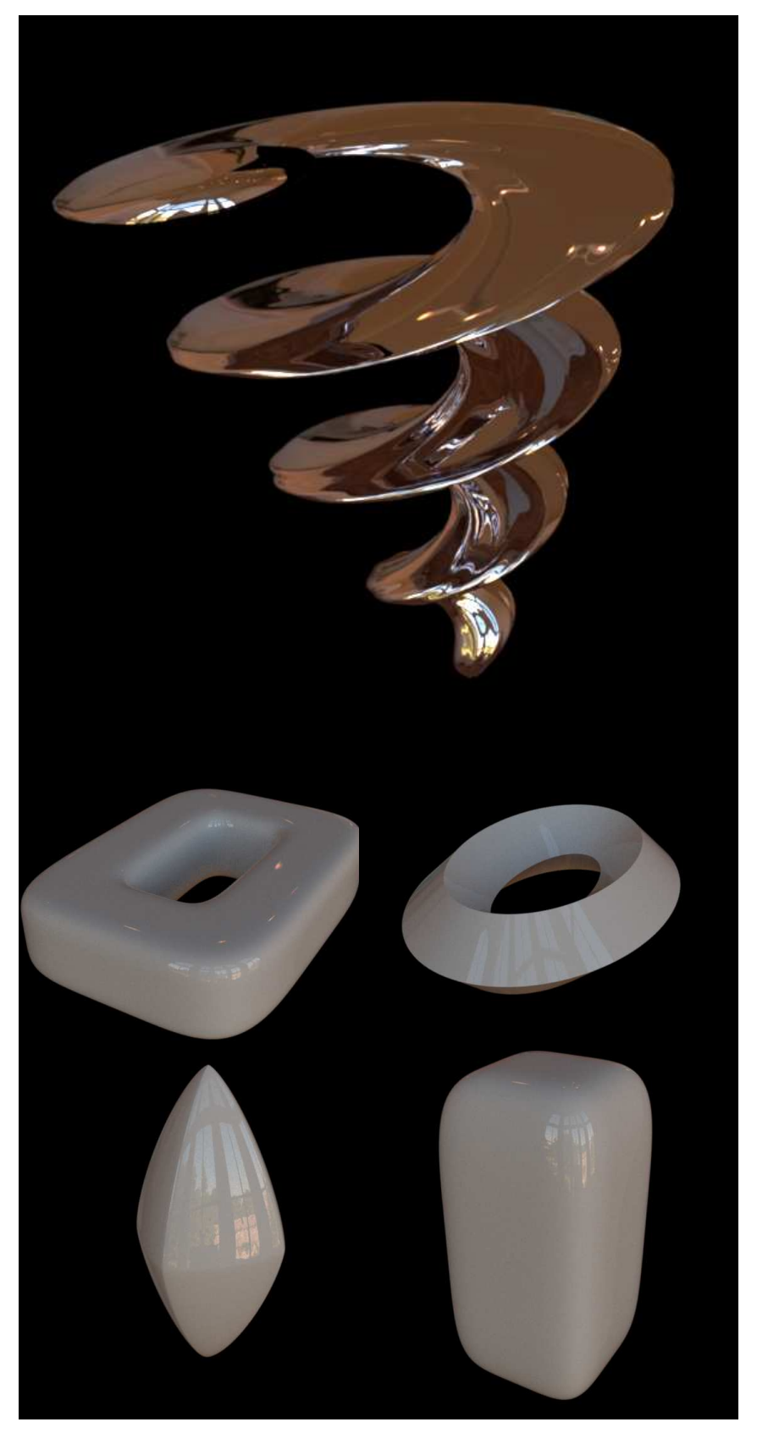
- Surface of revolution, spiral midline:

```
y = linspace(0,1,256);
x = 2*sin(8*pi*y).*y;
z = 2*cos(8*pi*y).*y;

profile = y.^.5;
m = objMakeNoise('revolution',...
                 [8 1 0 30 .03],...
                 'rcurve',profile,...
                 'spinex',x,'spinez',z,...
                 'caps',true);
```

- "Super-torus" and "super-ellipsoid":

```
tor = objMakePlain('torus','super',[.5 .5],...
                   'radius',[1 2]);
ell = objMakePlain('ellipsoid','super',[1.5 1.5]);
```



GUIs and other options

- The functions are most useful and versatile when called from your own code, but
- There are two graphical tools that help in designing new shapes:
  - `objDesigner` — GUI for creating models
  - `objBlendGui` — GUI for blending models
- Several other options and tools for, e.g.
  - Vertex groups
  - Surface normals
  - Texture coordinates

Prepare for 3D printing

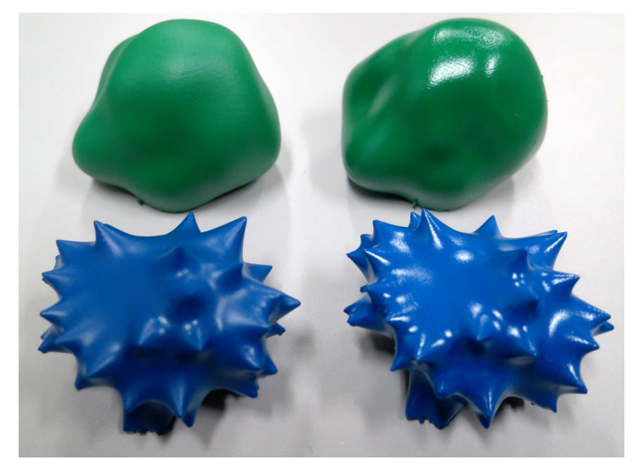
Tools for

- Adding wall thickness
- Scaling the model
- Cutting a piece out (for SLA printing, to avoid a "suction effect" with a closed, hollow shape)

```
% Make a sphere with bumps and dents
m = objMakeBump('sphere',[50 pi/16 .1; 50 pi/16 -.1]);
m = objScale(m,20);       % scale to bigger size
m = objCutSphere(m,16);   % cut a piece out
m = objAddThickness(m,5); % wall thickness
m = objSet(m,'filename','sphere_for_print');
objSave(m);               % save
```

Rendered

3D-printed



All images rendered with Mitsuba renderer: Jakob (2010). Mitsuba renderer. http://www.mitsuba-renderer.org.

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