6. Complex Curvature

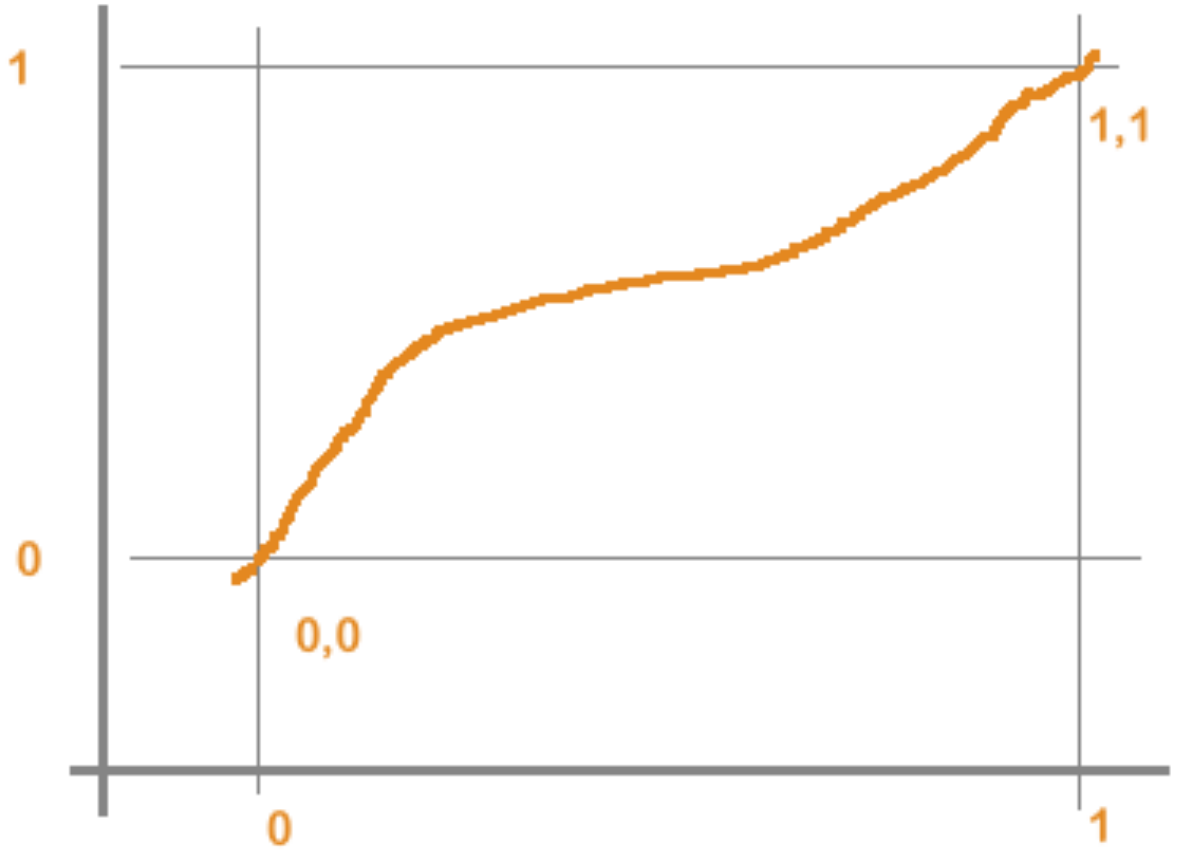
(mostly) Indirect Control of Shape

Non Uniform Rational Basis[1] Splines

aka … NURBS

[1] A variation on a Bezier curve

Parametric representations



Parametric representations

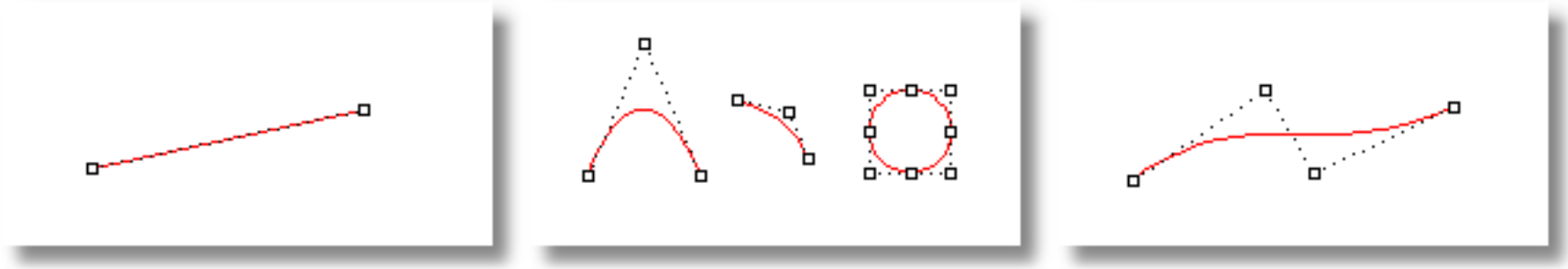
- Approximate line with polynomial equation

  $y = a_n x^n + a_{(n-1)} x^{(n-1)} + \ldots + a_1 x + c$

- Parameterize in terms of a parameter "t"

  $y = a_n t^n + a_{(n-1)} t^{(n-1)} + \ldots + a_1 t + c \quad over\ t=(0, 1)$

- Polynomial degree (largest exponent) determines kind of curve you can represent.



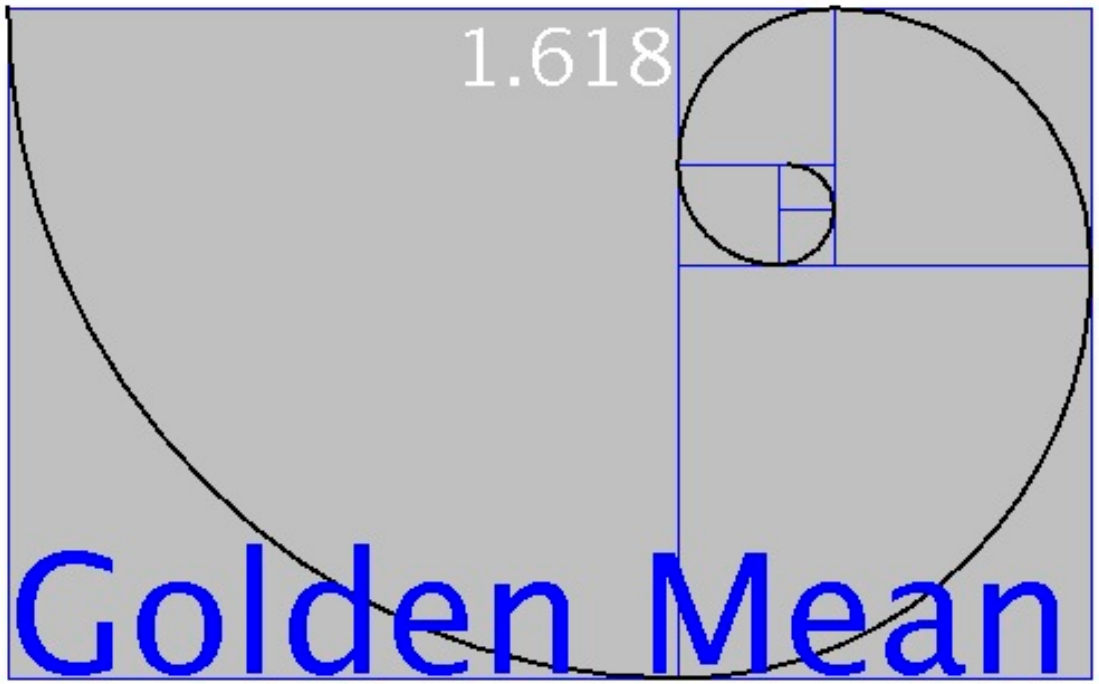
Degree 1 Degree 2 Degree 3

Parametric representations

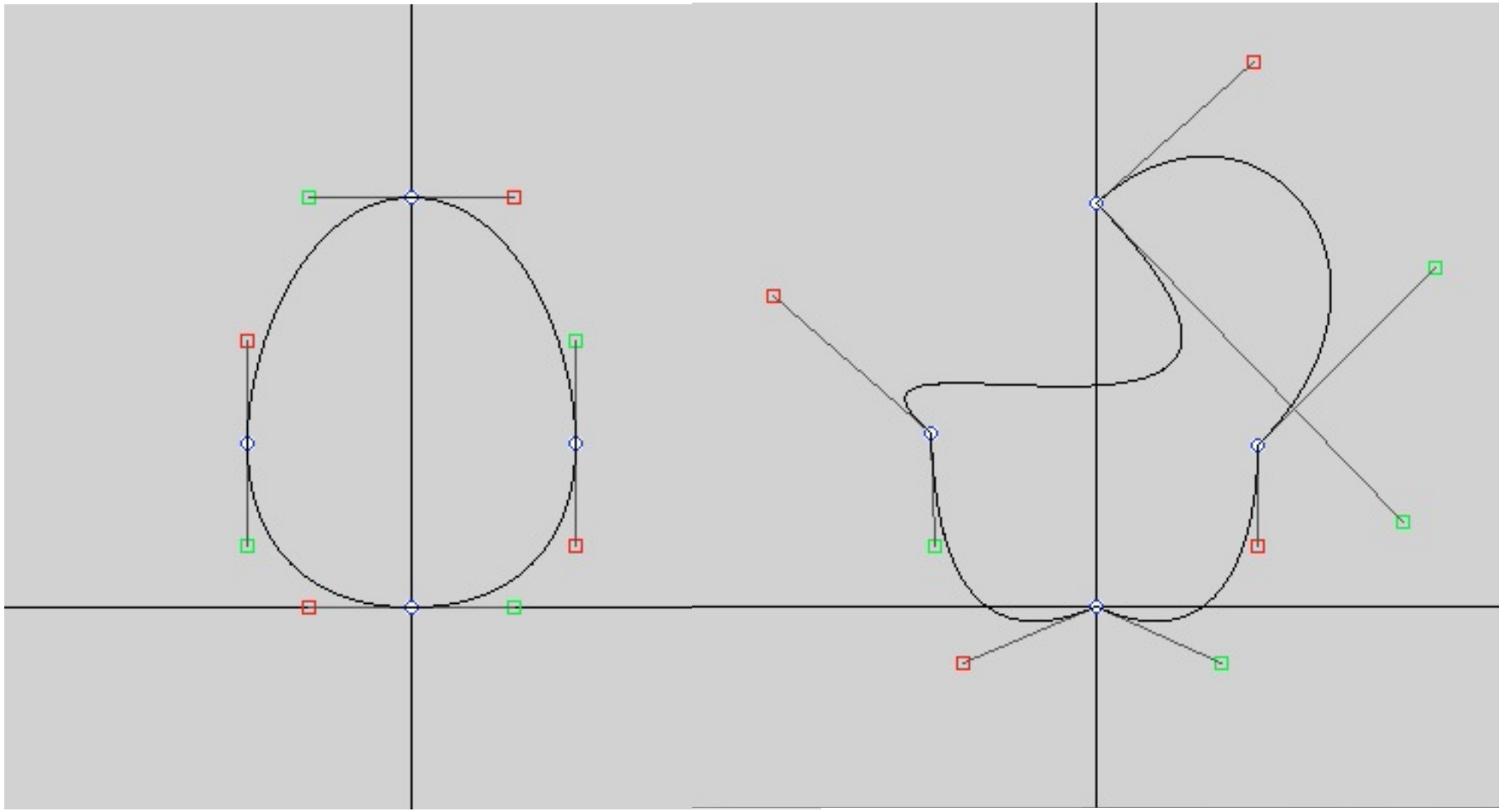
- Control points determine parameters
- Complex curves can be pieced together
- Three levels of "continuity" between pieces
  - *C^0: Positional*
  - *C^1: Slope of tangent*
  - *C^2: Radius of curvature*

The Golden Spiral

Just how continuous is it?

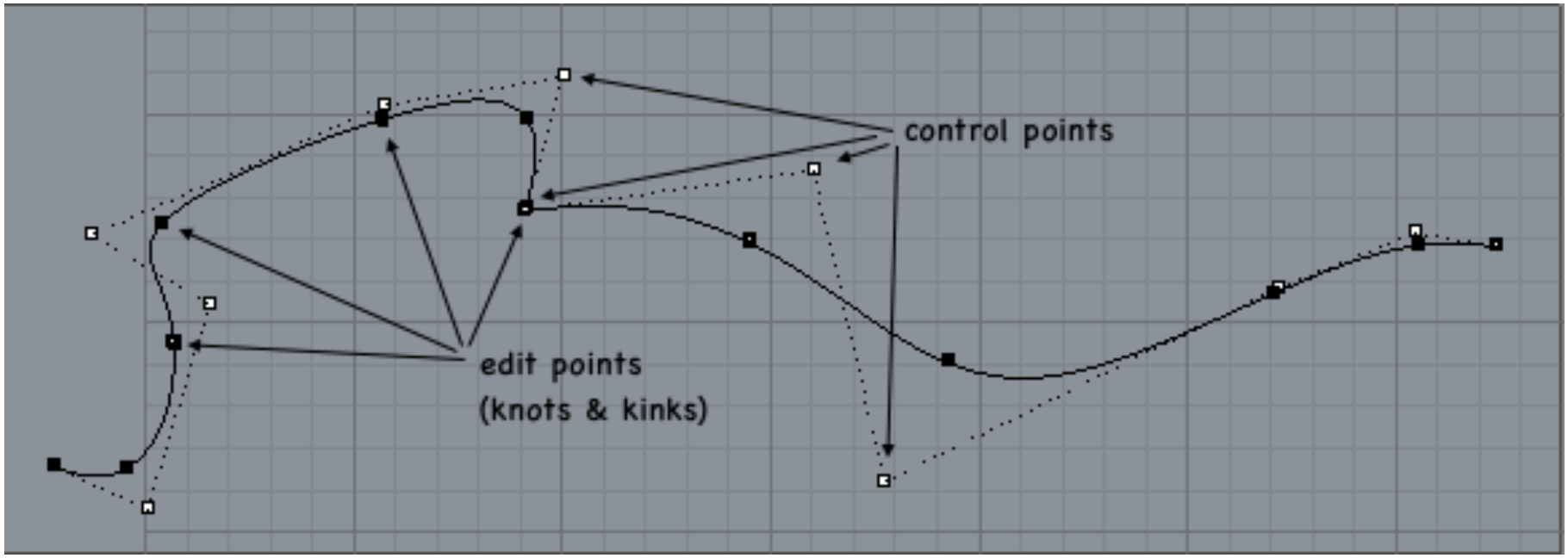


A 4-curve *Bezier playground*:



http://quicksilver.be.washington.edu/java/bezierPlayground/

Control Point Vocabulary



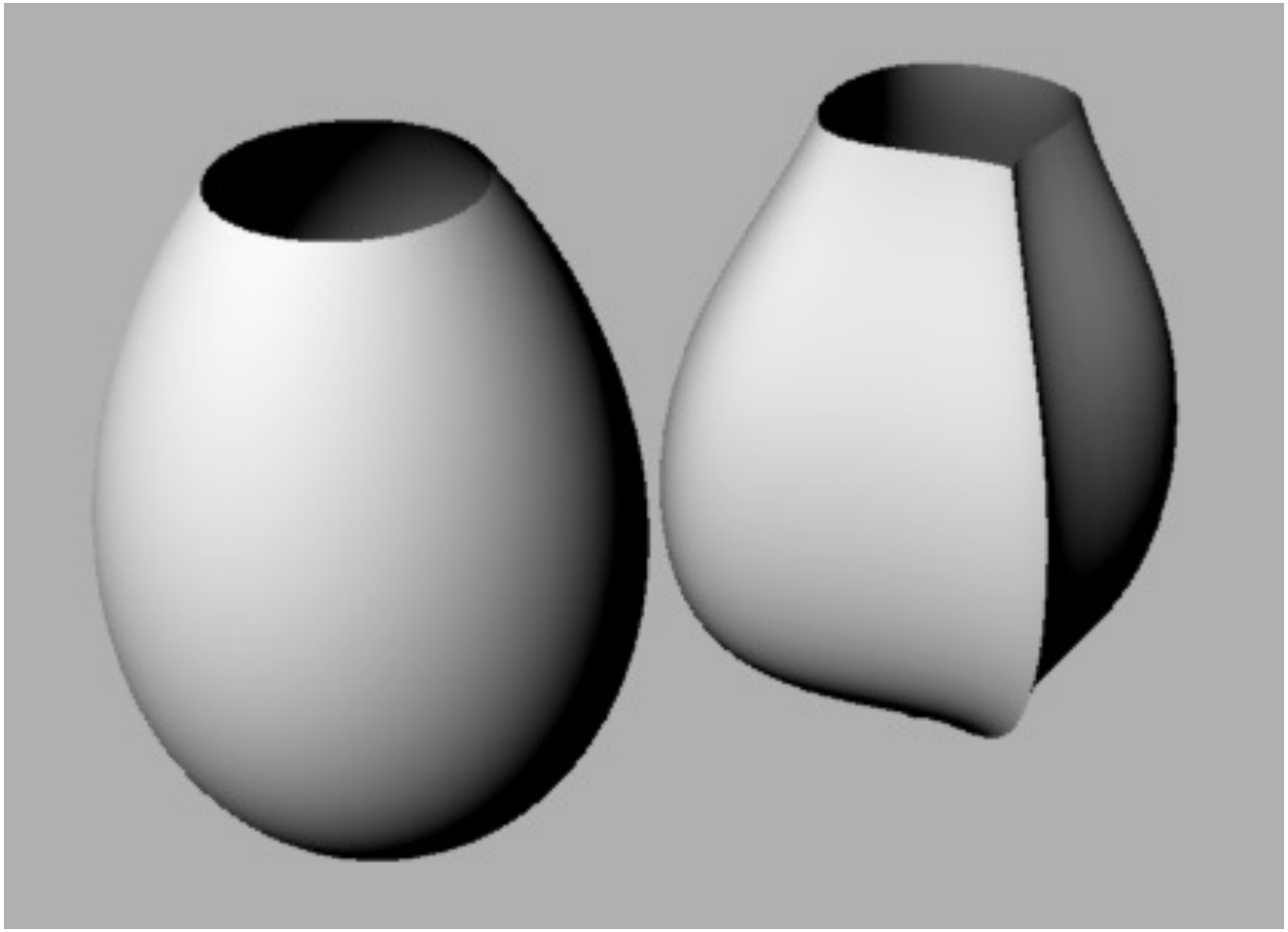
Edit points are points the line passes through, either preserving continuity of slope (knots) or with an optional change of direction (kinks)

Control points are the off-curve points that guide or control the curve. “Weights” are numbers describing the “pull” of any one control point on the curve.

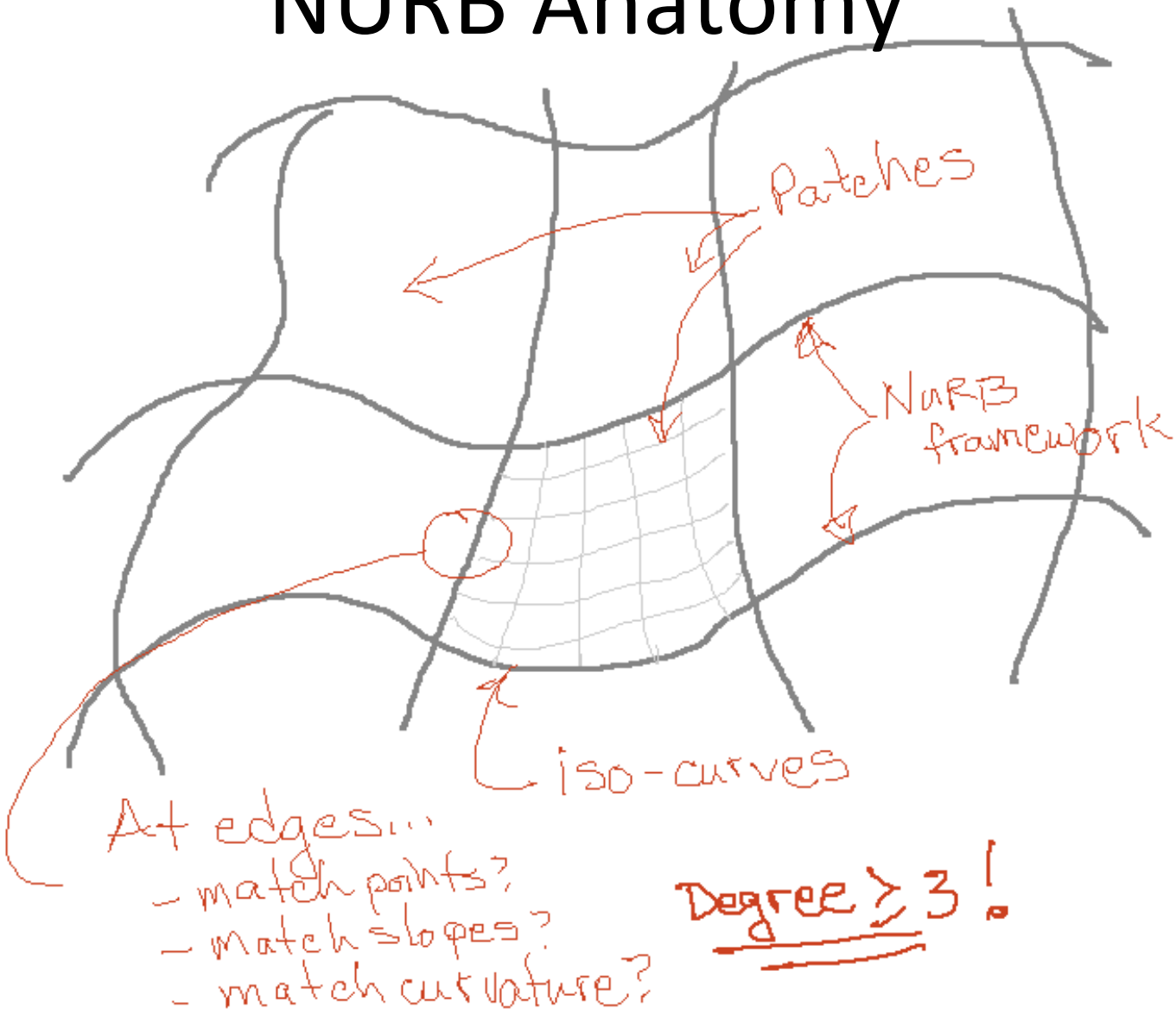
Parametric representations

- End-points, tangency and closed curves ("seams" & "deformable" rebuilds)
- Higher-degree polynomials can exactly match lower-order polynomials, but not vice versa.
- Control points "pull" curve towards their location with a "weight" that is editable.
- "kinks" allow corners (C^0 continuity only) if desired

Continuity (*MakePeriodic*)



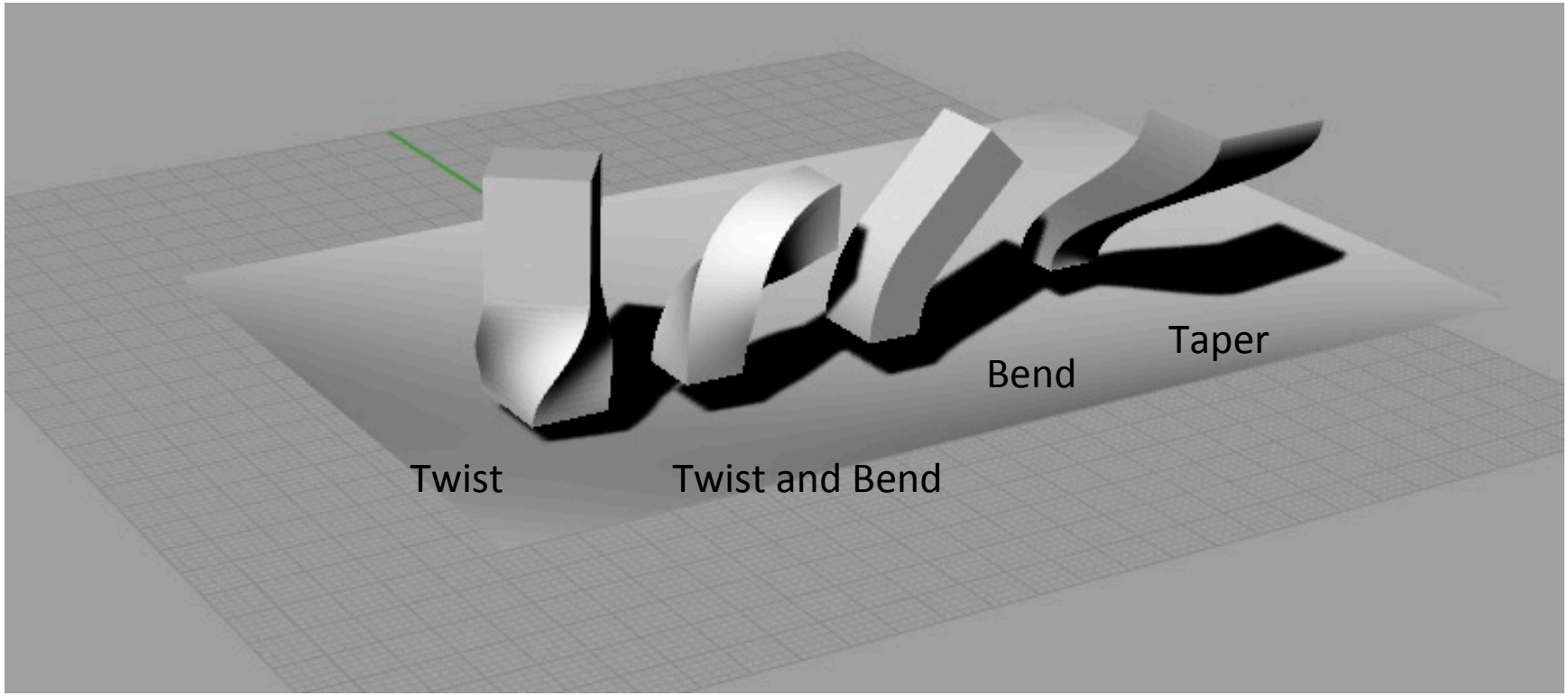
NURB Anatomy



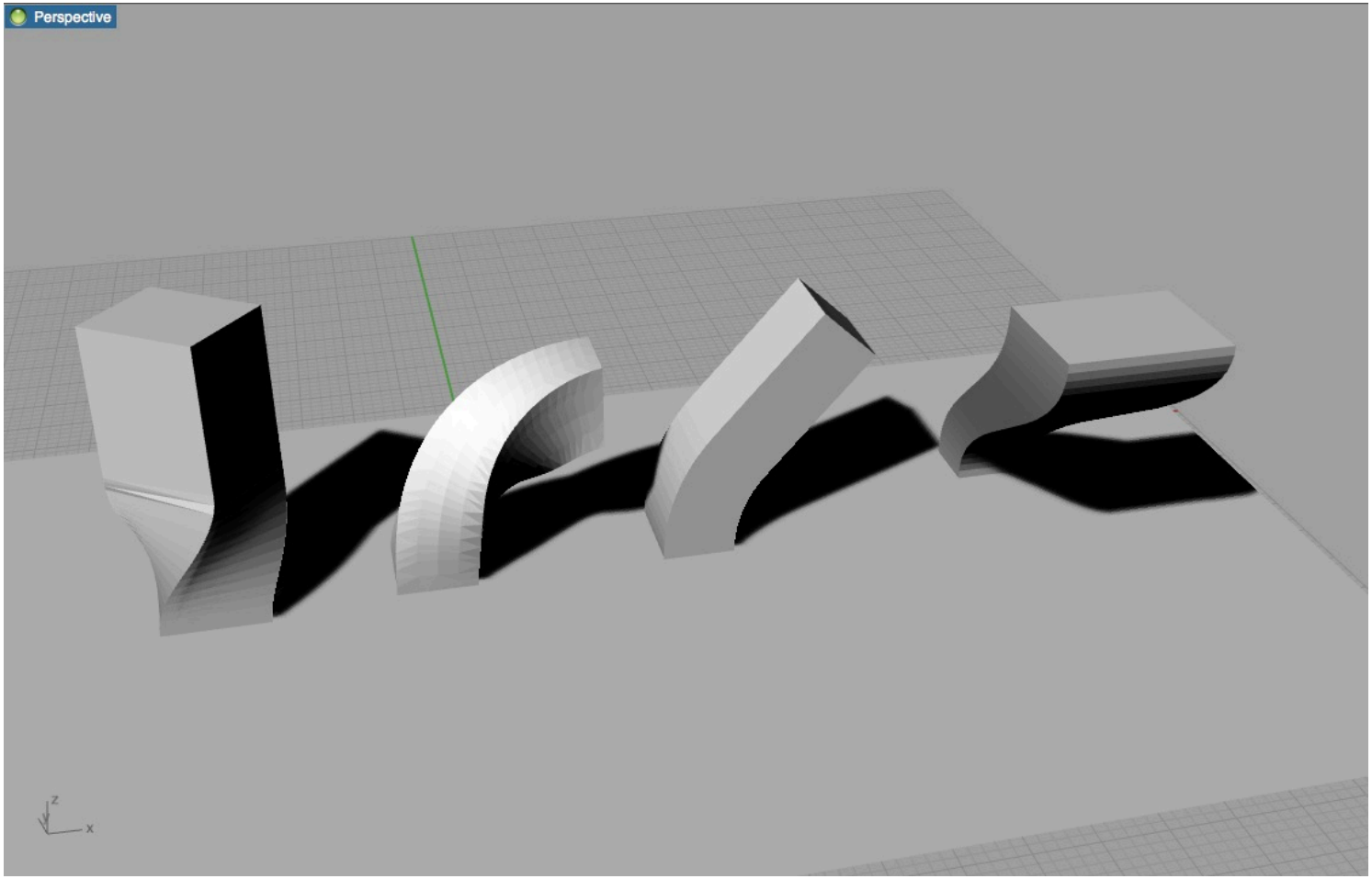
Editing NURB Curves & Surfaces

- *Rebuild* (going nuclear w/ new controls)
  - Generate new control point grid
  - Adjust NURBS degree (1..11, but best if <= 3)
- *ChangeDegree* (changing NURBS degree)
- *MakePeriodic* (completing the circle)
- *InsertKink* (changing continuity requirements)
- *InsertControlPoint* (changing control points)
- *Weight* (changing control point influence)

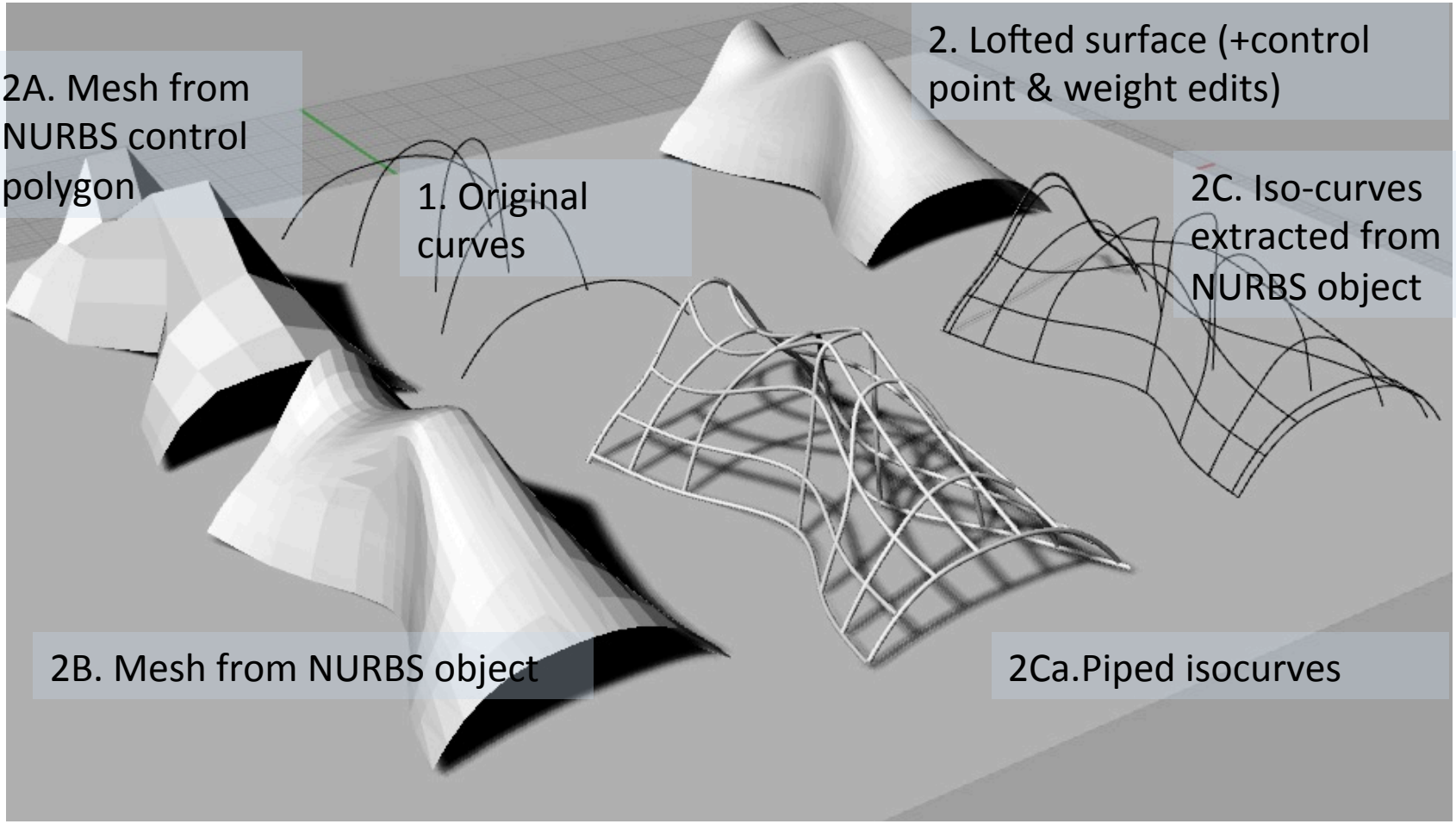
Transformations of NURBS



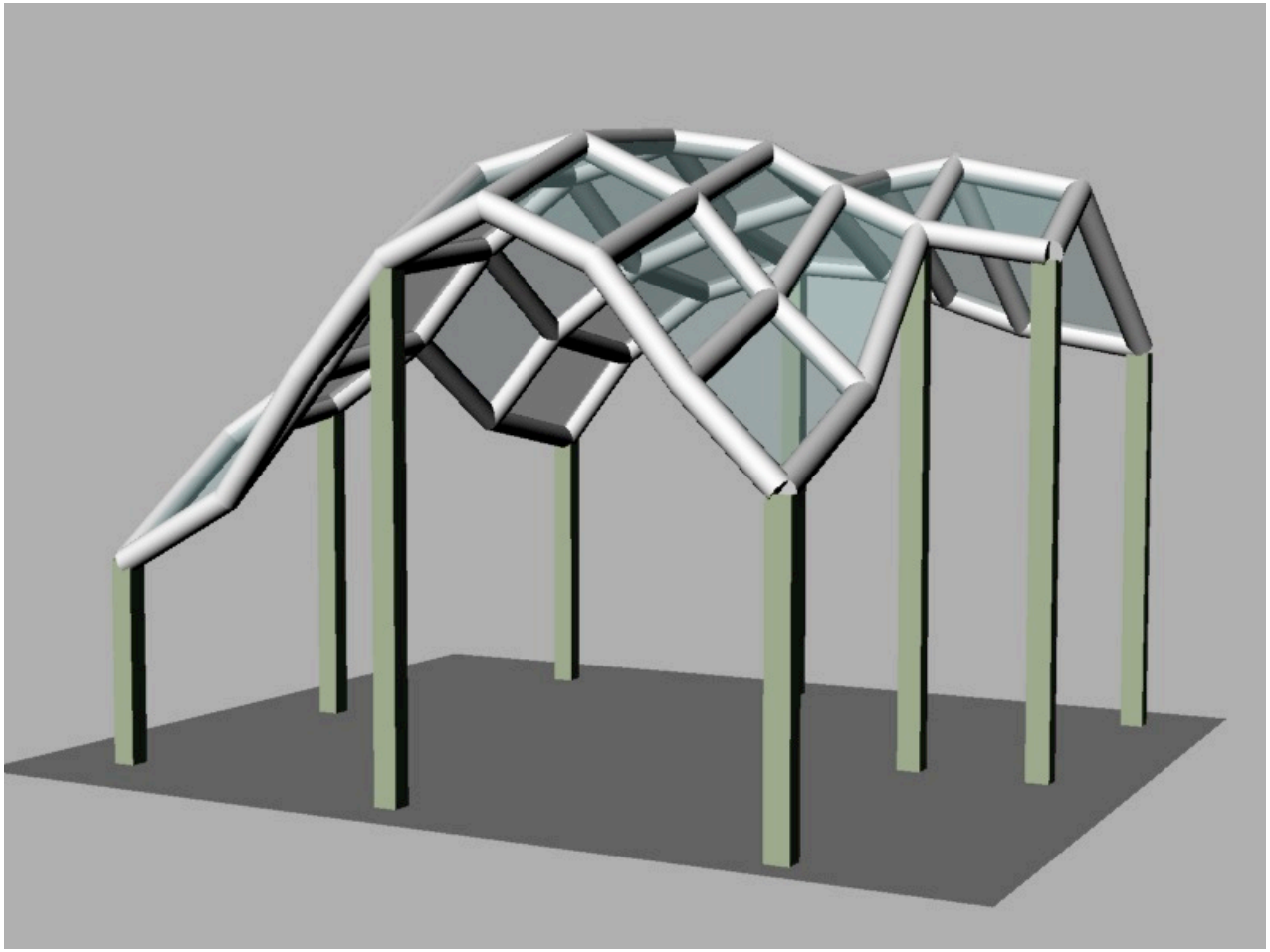
(flat shading shows lots of polys!)



Curves to isocurves (& meshes!)



A Gazebo Roof



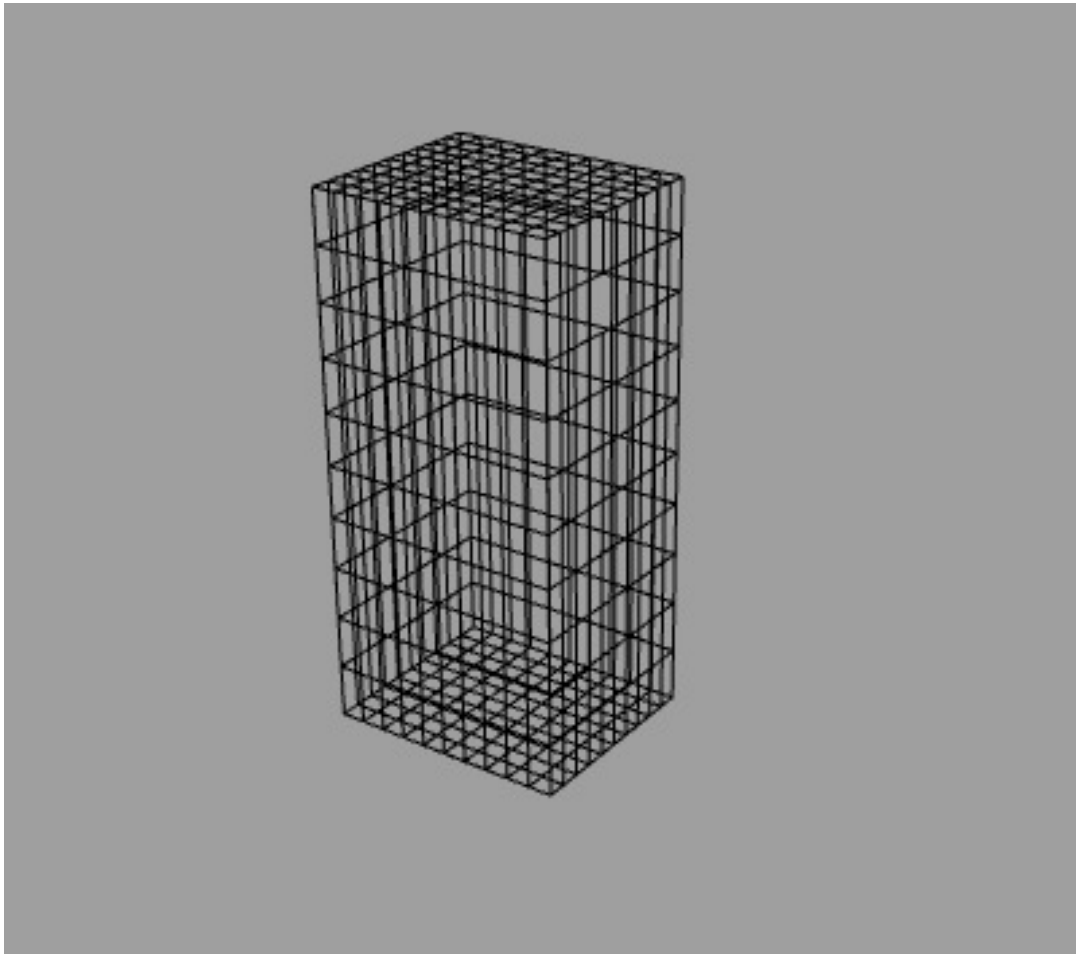
Mesh Manipulation

Control-point-editing,

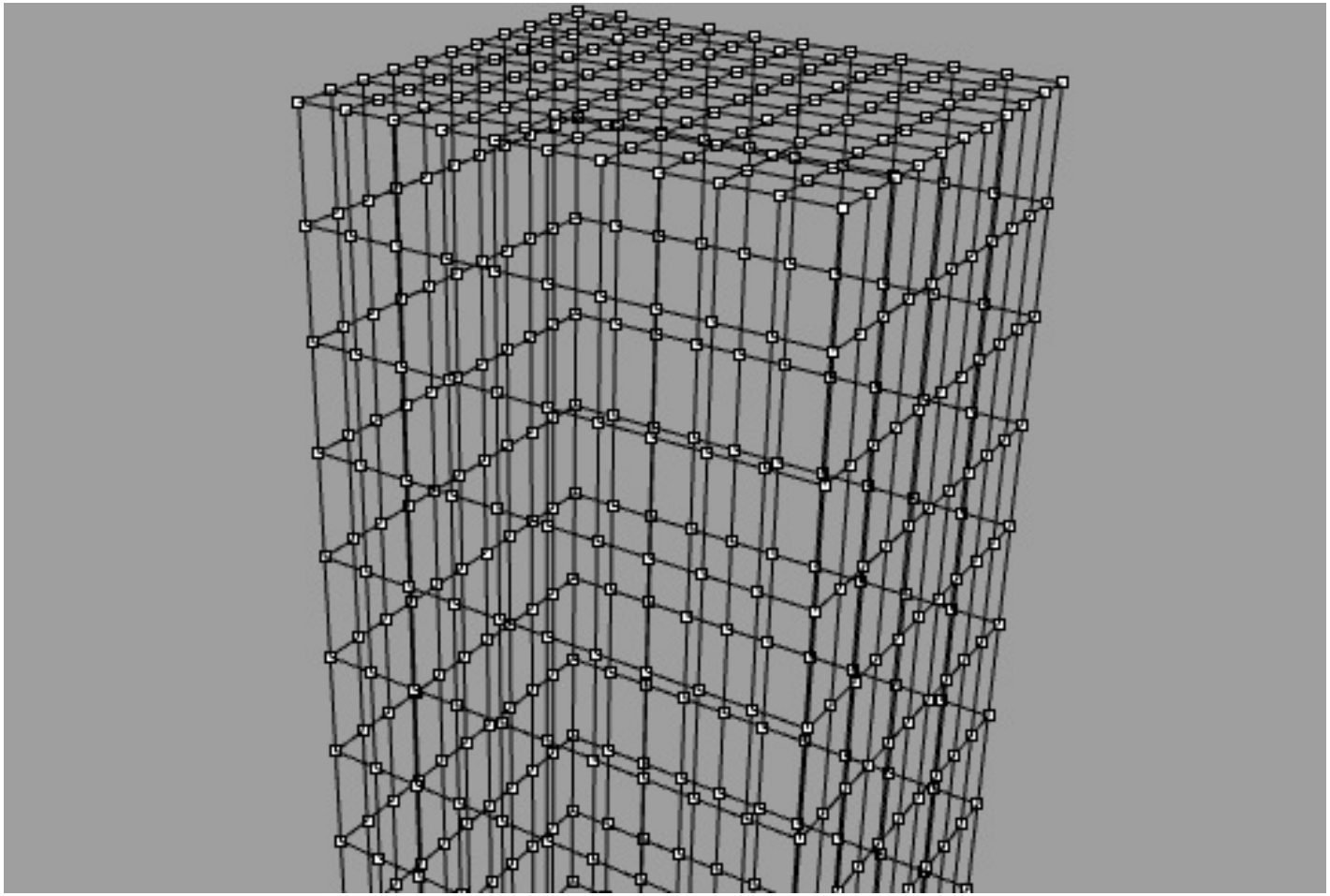
Transformation,

Cage Editing

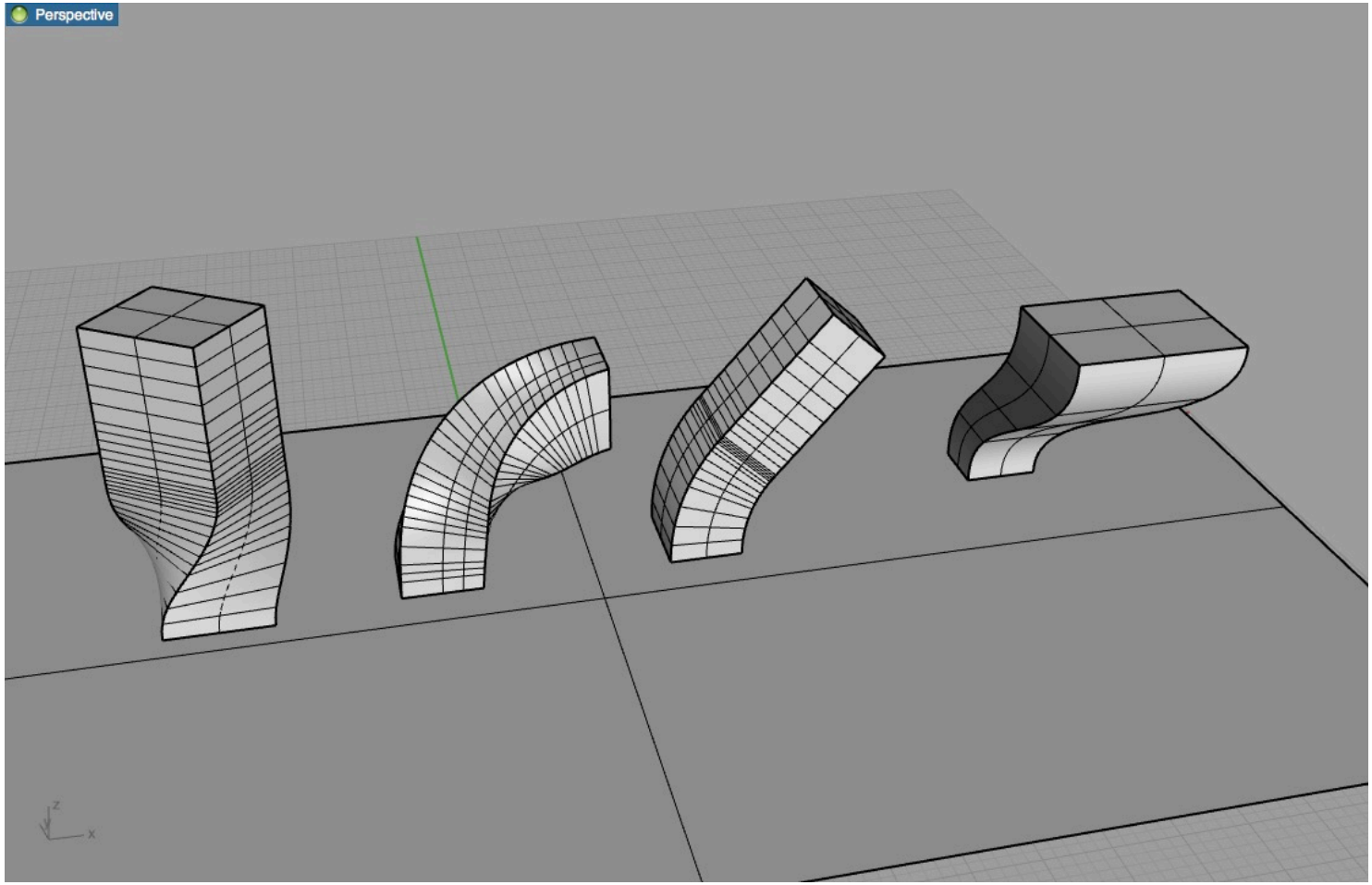
Mesh > Box (divide & conquer!)



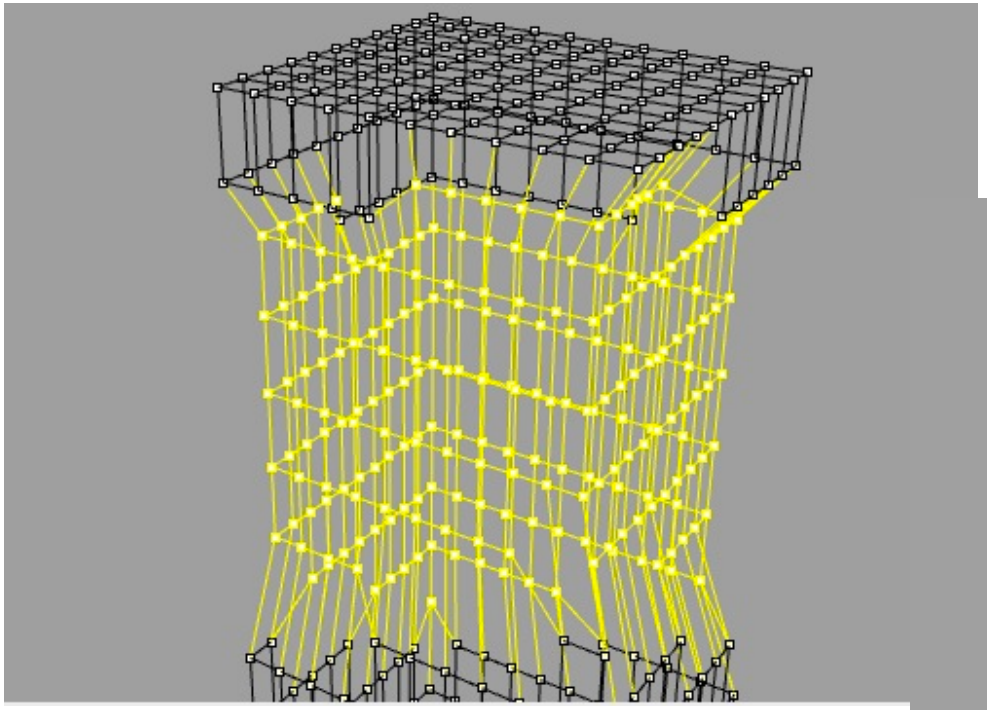
Control Points On [f10]

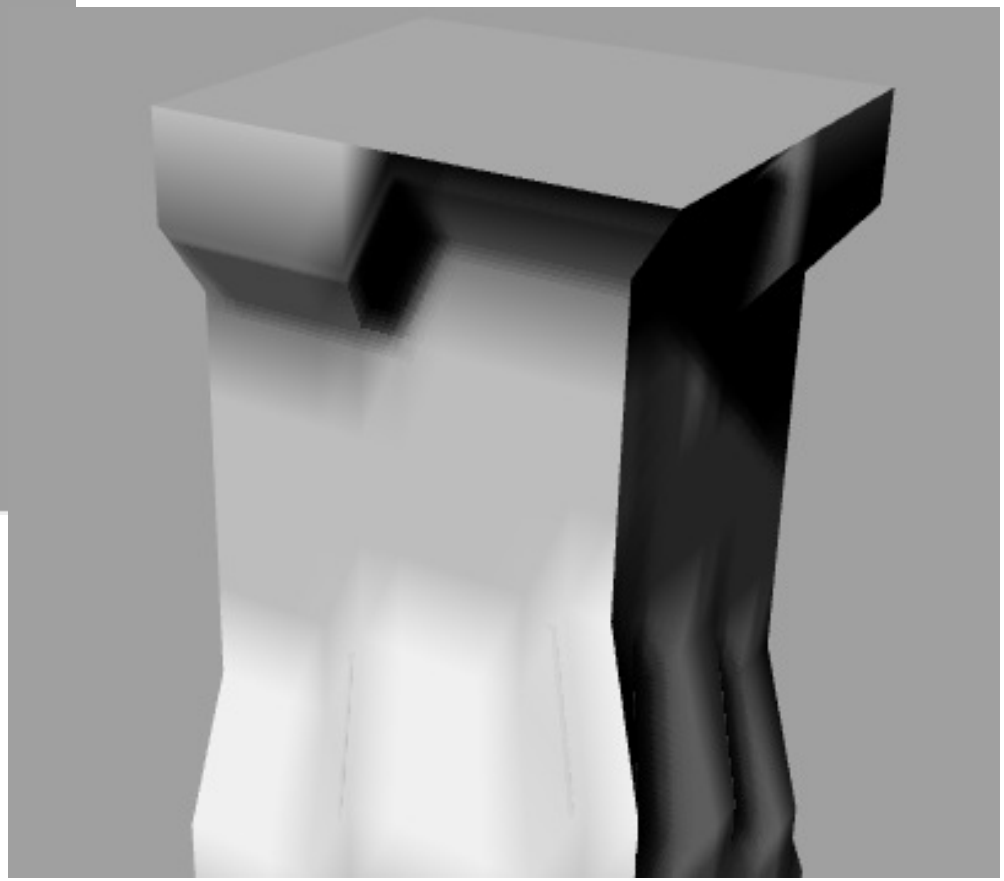


Manipulating many points

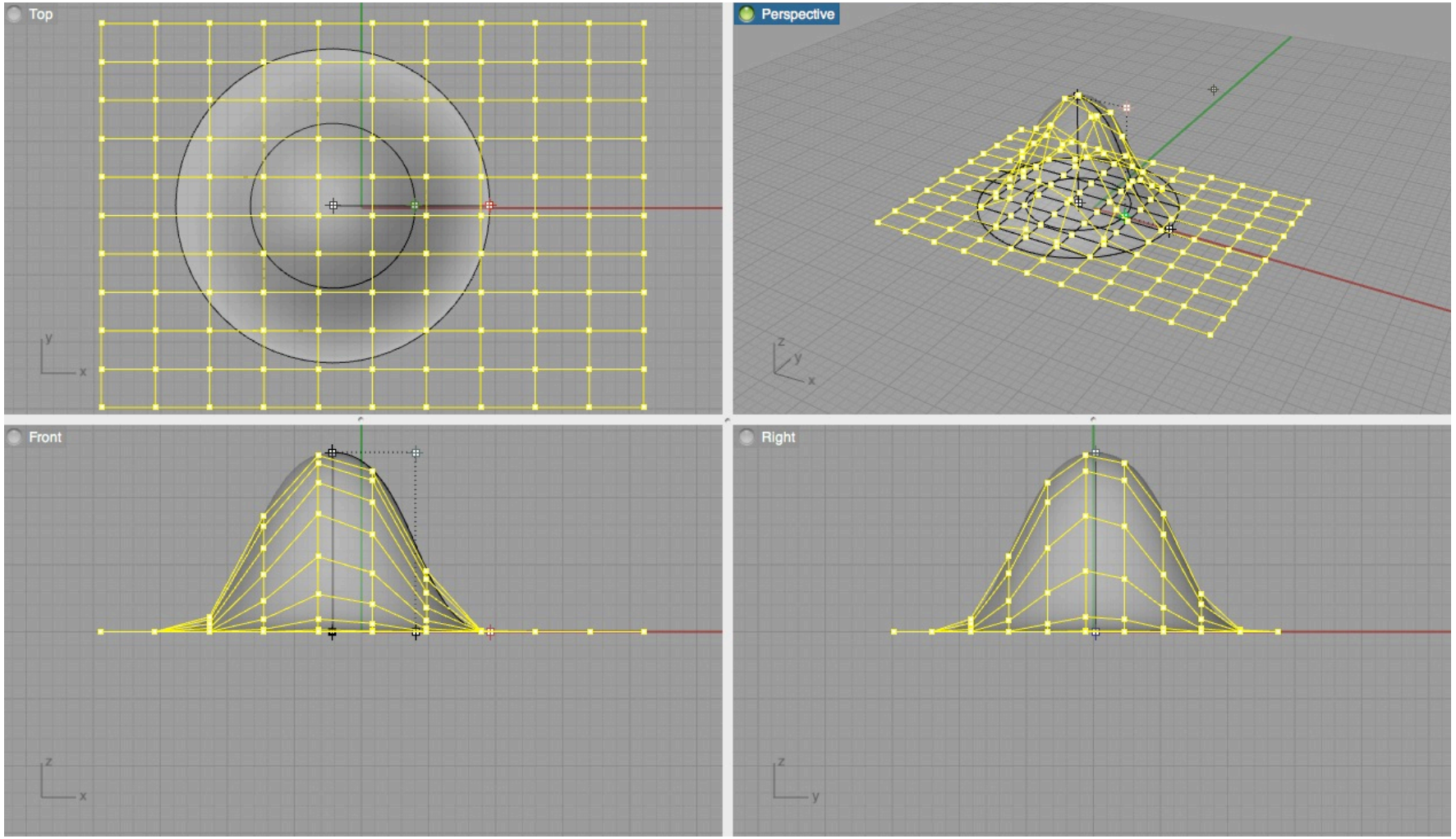


More Transformations: scale

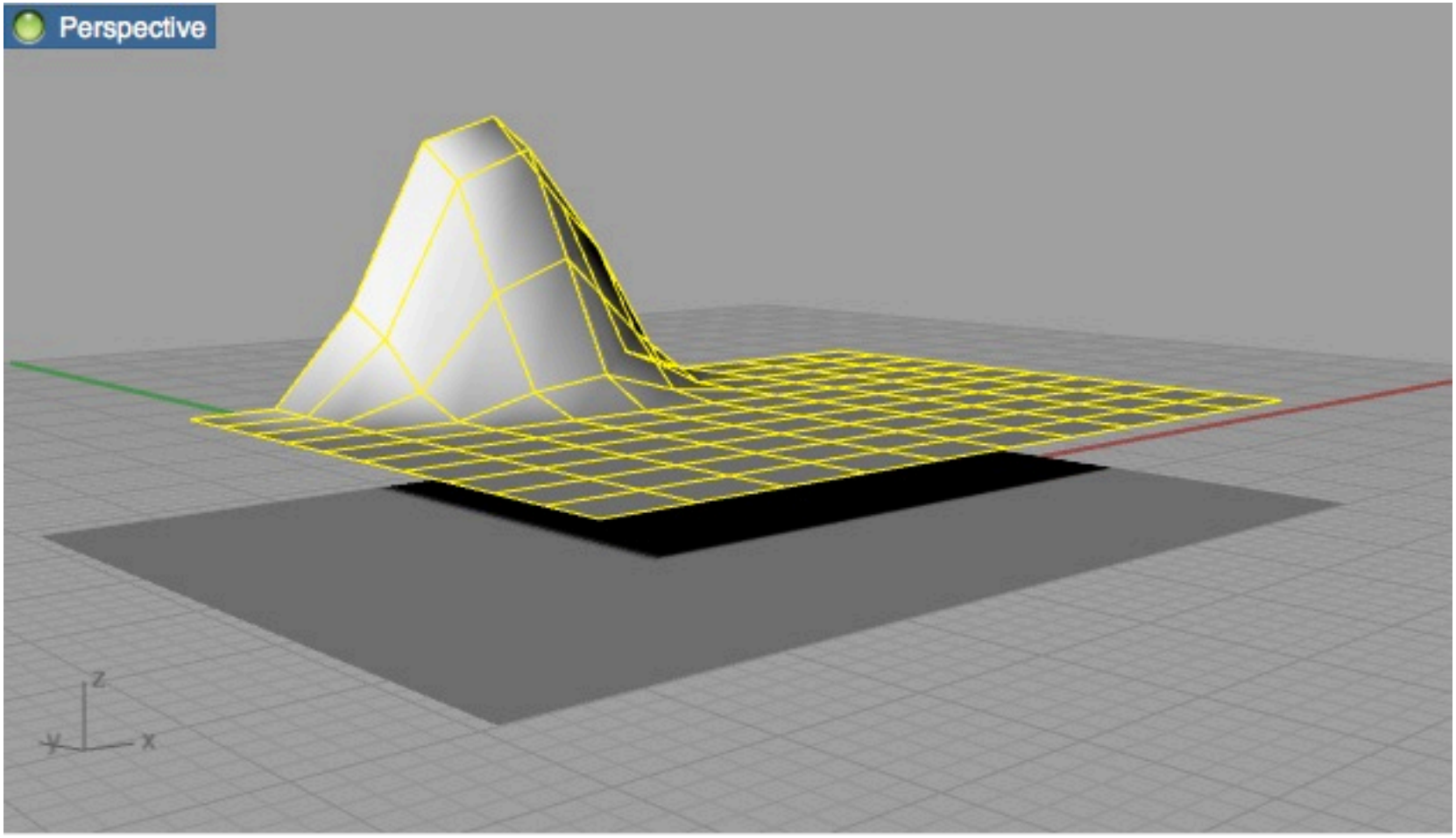




More Transformations: Soft Move



More Transformations: Soft Move

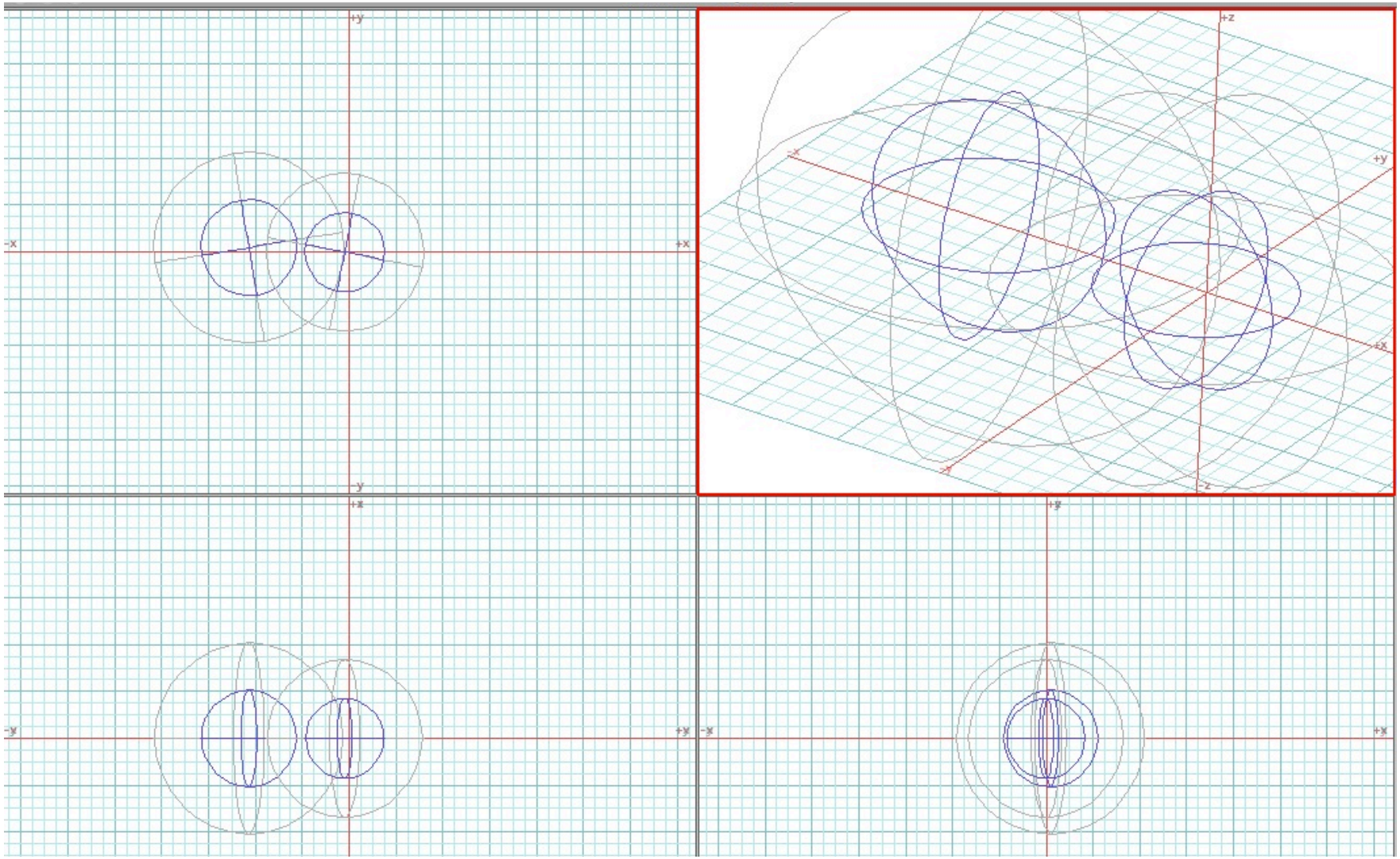


Iso-*surfaces* (aka Meta-forms)

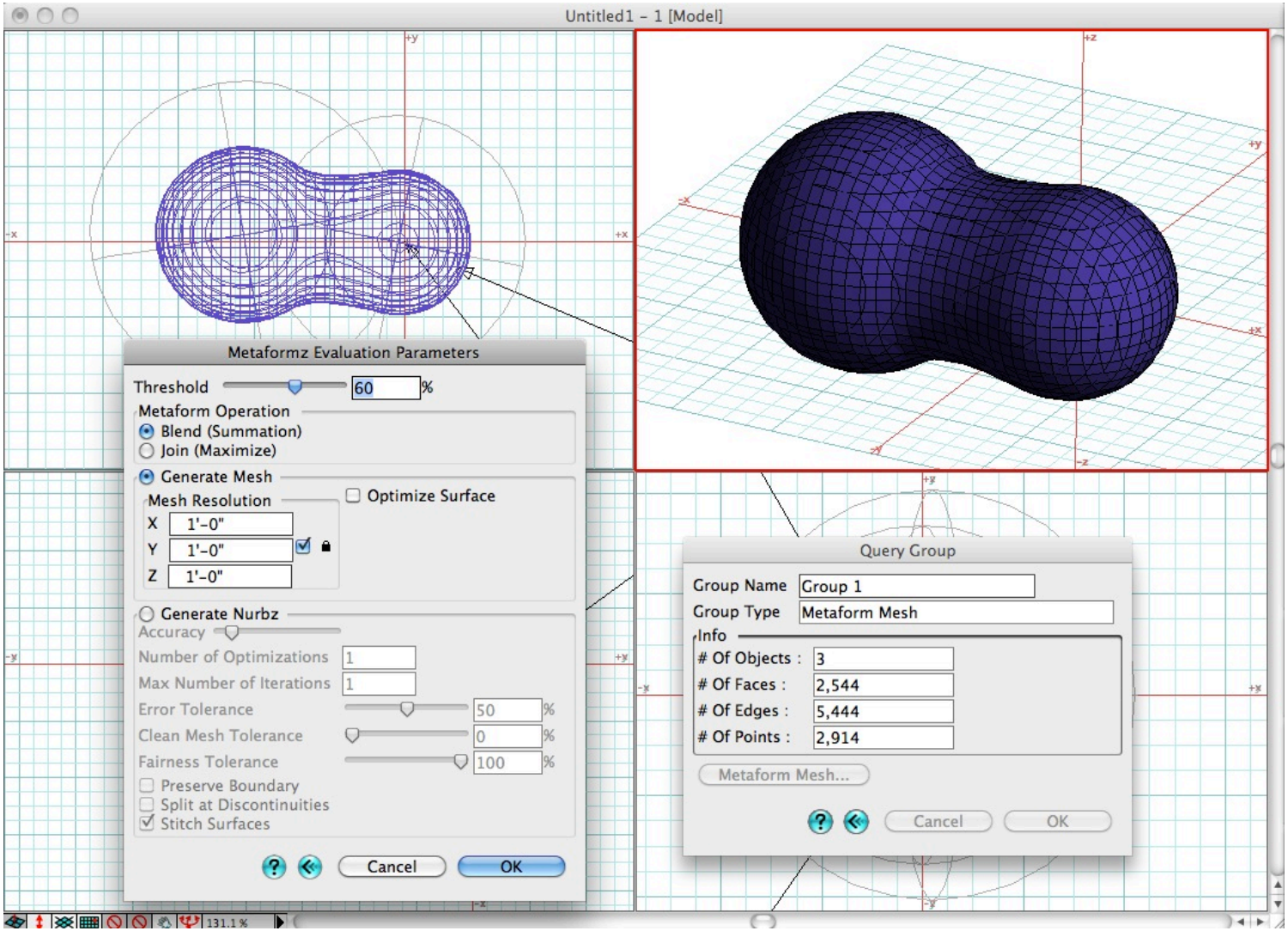
NOT “meat-balls”

(not a Rhino feature)

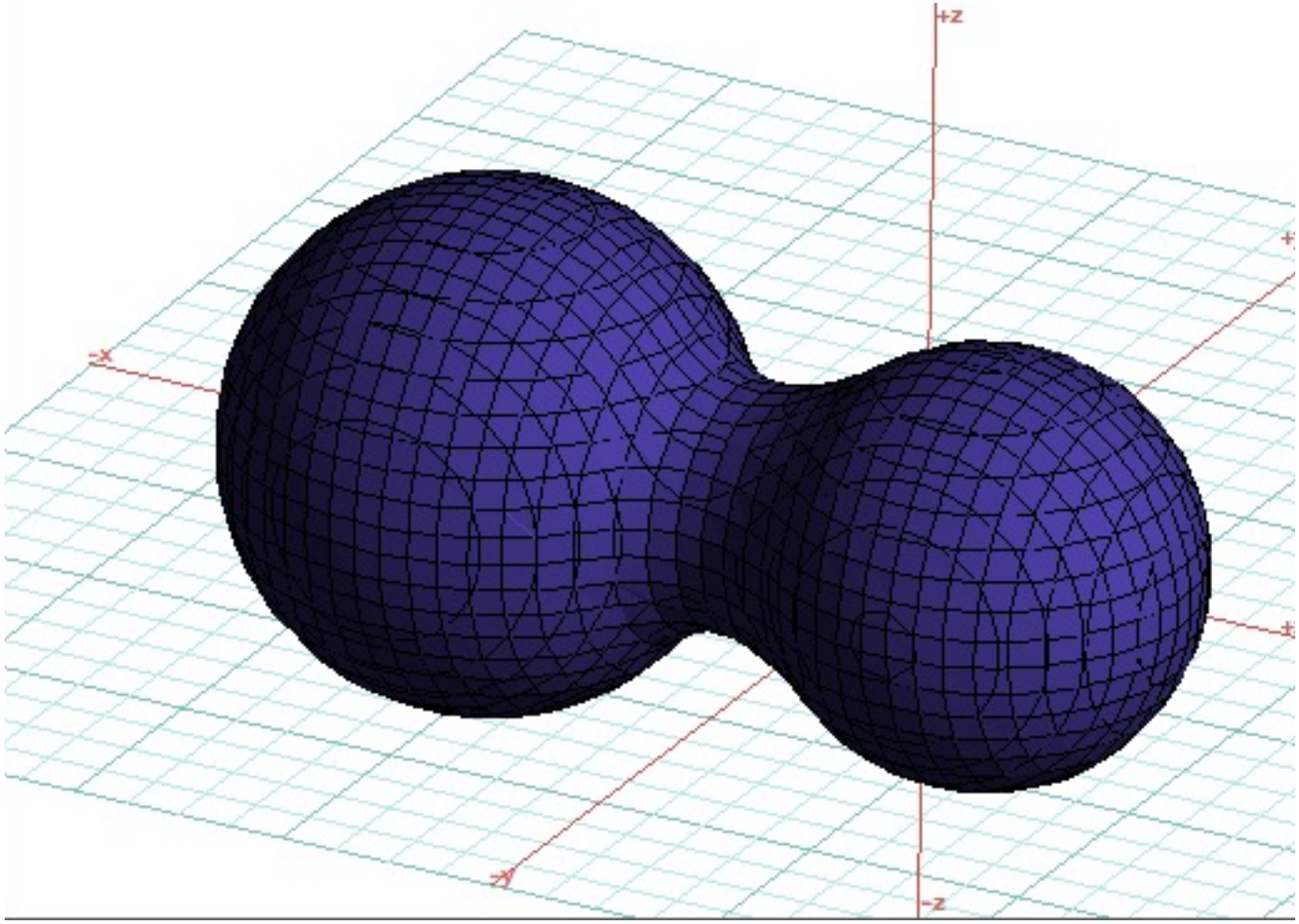
(form•Z) Meta-balls



(form•Z) **Meta-balls**



(form•Z) **Meta-balls**



6. Complex Curvature

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