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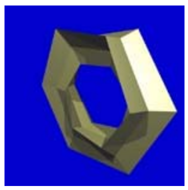
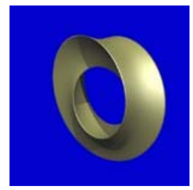
Chapter 13

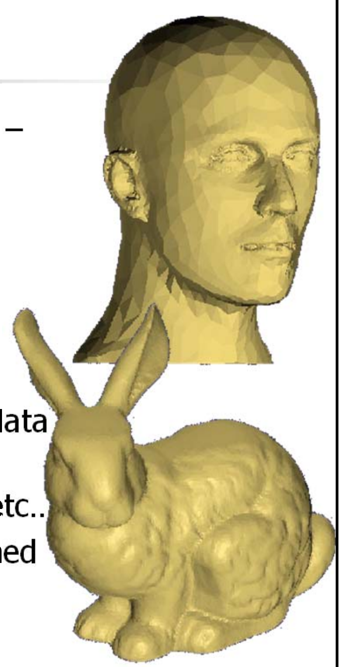
Geometric Modeling
Meshes & Subdivision





Meshes

- Simplest boundary representation – polygonal mesh
- Properties
  - Triangular/Quad
  - Manifold
- Simplicity of representation & manipulation
- Base representation for scanned data
- Input to hardware rendering algorithms (Z-buffer, polygon fill,etc..
- Manipulation algorithms well defined (computational geometry)



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Processing

- Construction
  - From scans
  - From free-form/volumetric data
- Compression – typical meshes are very large due to
  - Origin (scan)
  - Required LOD
- Manipulation
  - Note: No (u,v) parameterization
- Smoothing
  - Simulate via lighting methods
  - Refine - subdivision

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Subdivision Curves and Surfaces

- Subdivision – given polyline/polygon/polyhedron recursively modify its vertices to achieve smooth curve

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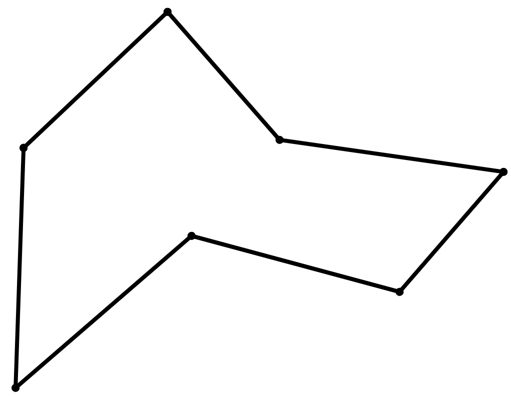
Corner Cutting



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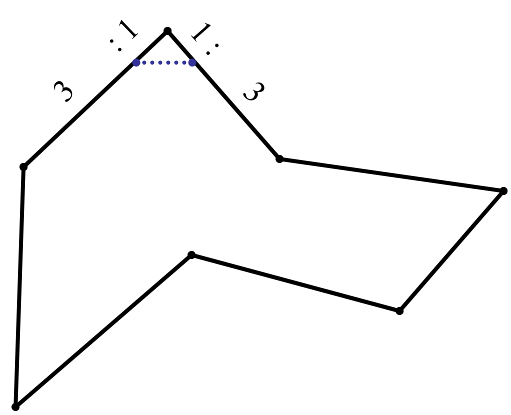
Corner Cutting



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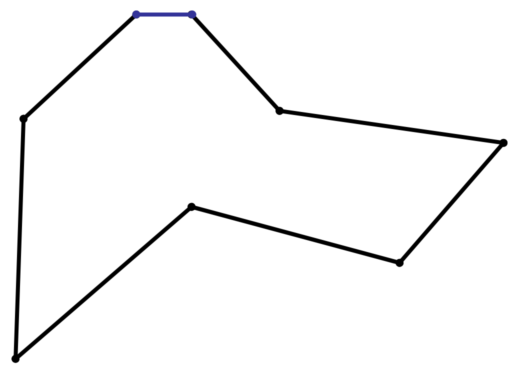

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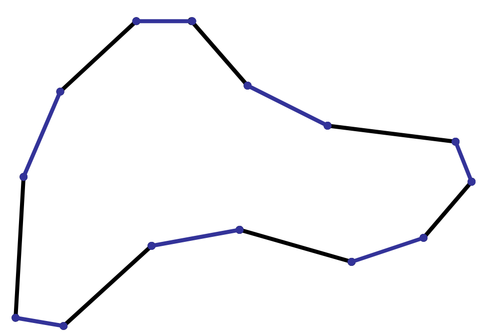

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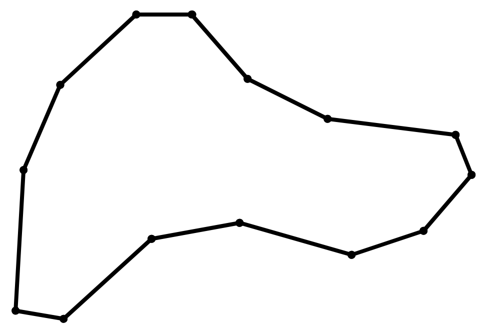

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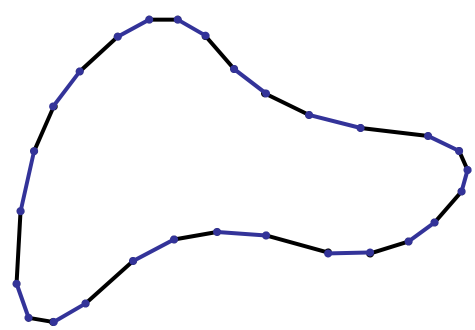

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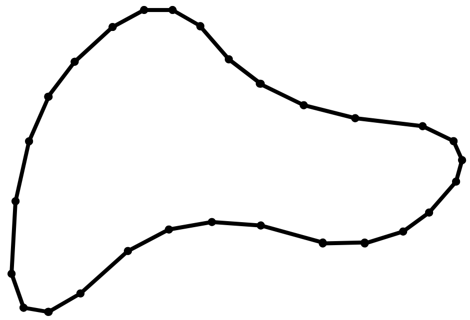

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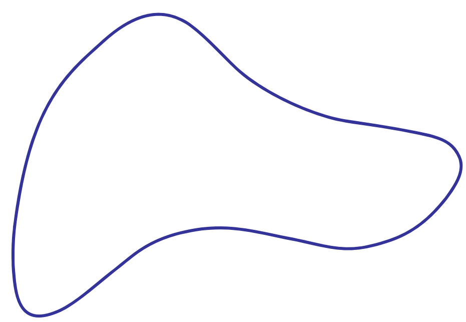

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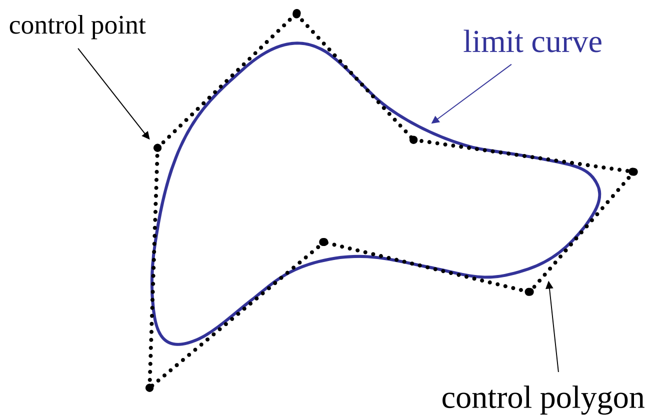

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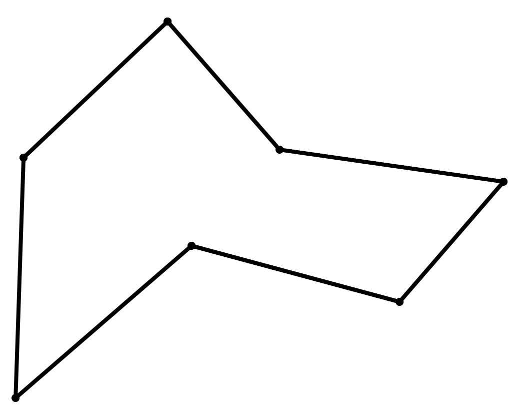
The 4-point scheme



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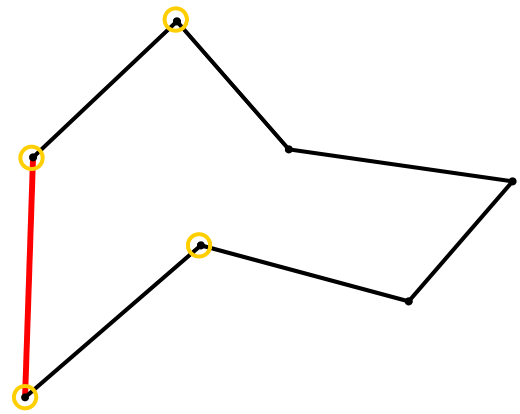

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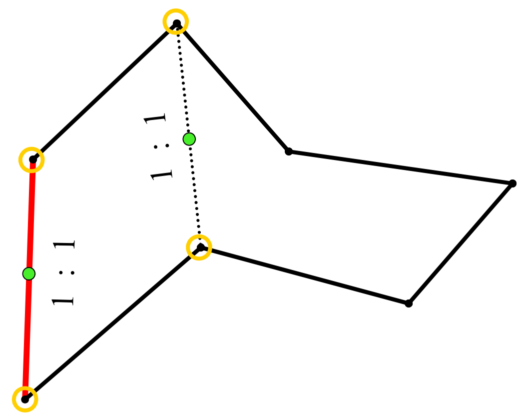

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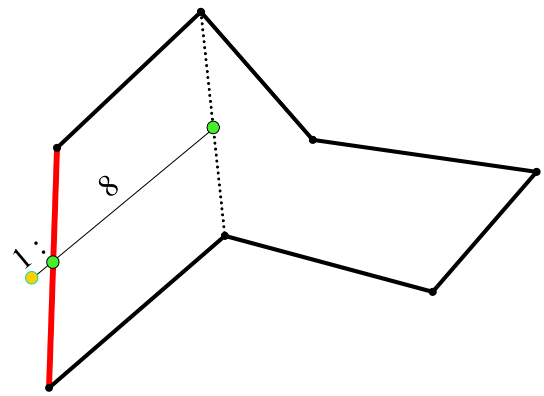

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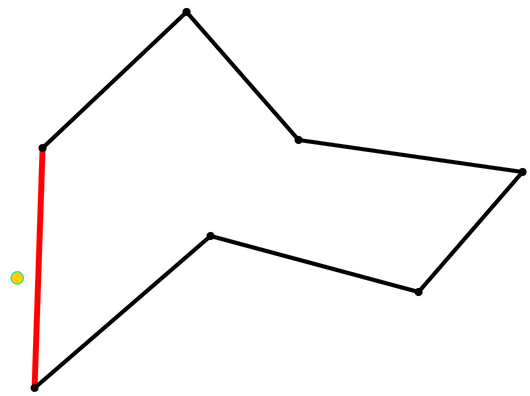

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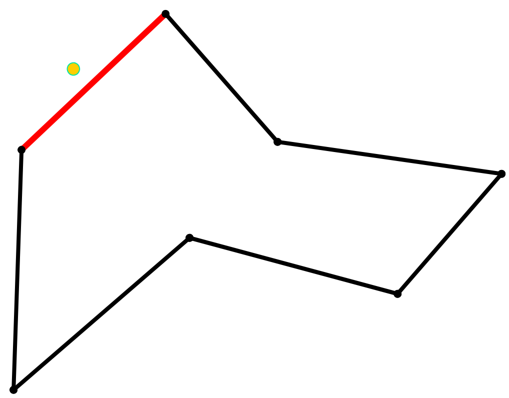

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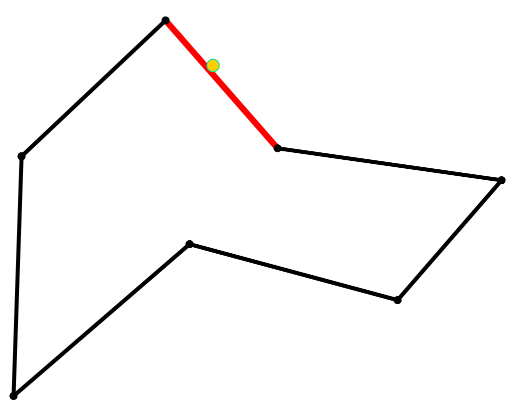

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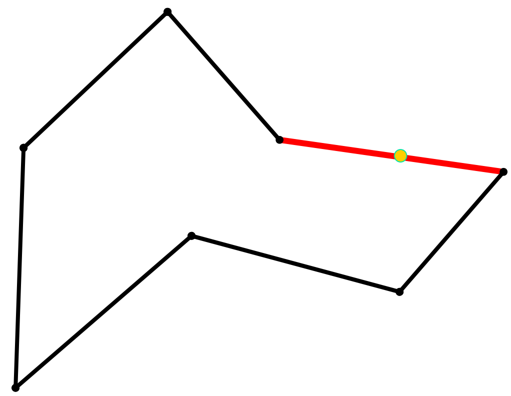

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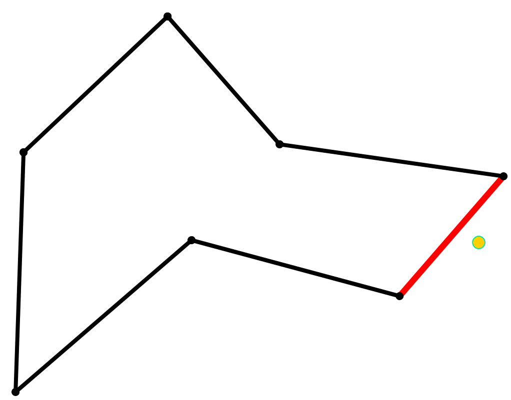

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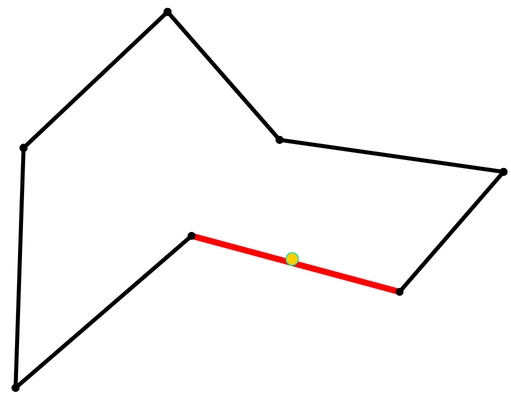

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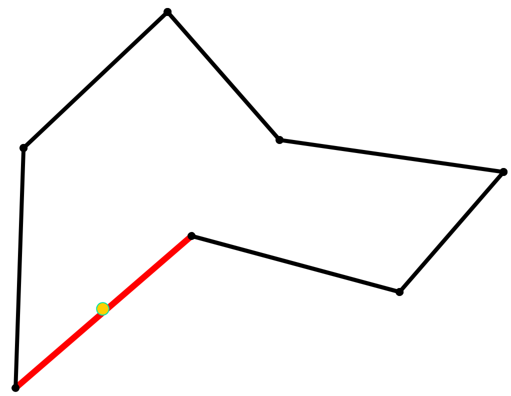

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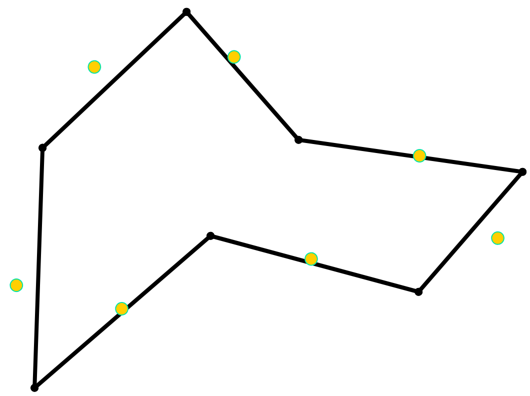

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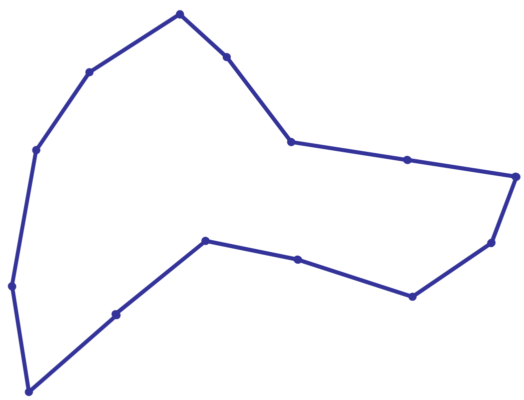

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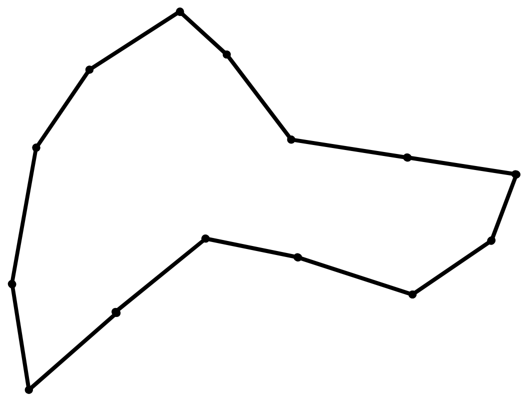

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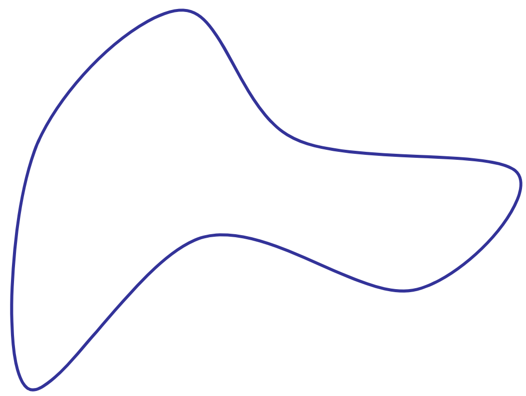

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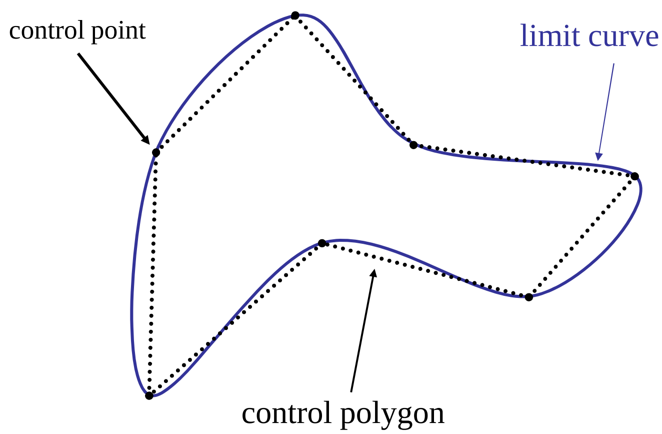
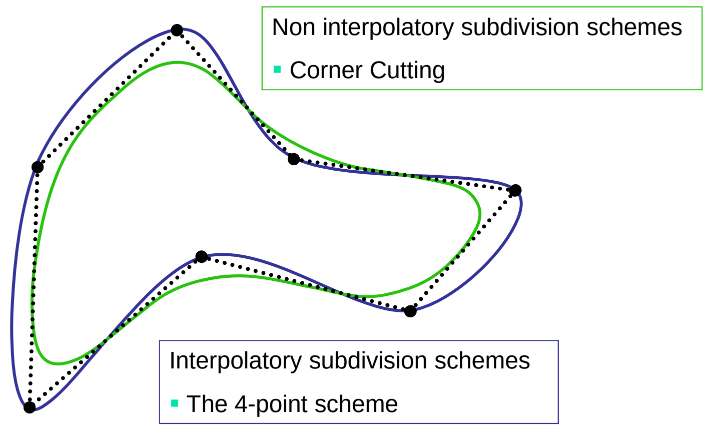
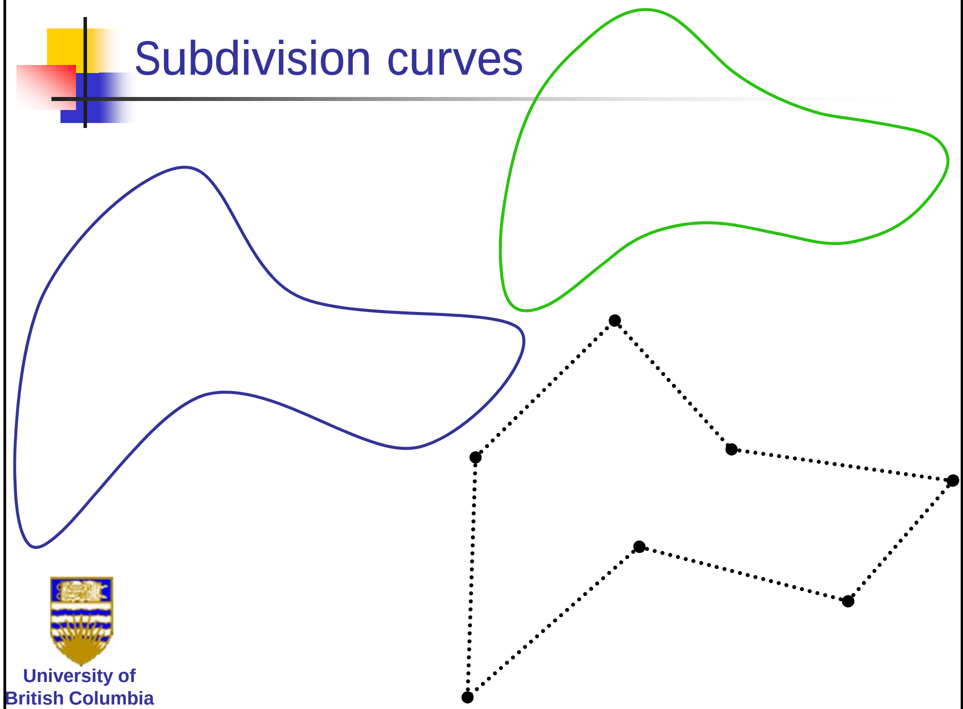


Subdivision curves



Subdivision curves



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Basic concepts of Subdivision

- Subdivision curve generated by repeatedly applying subdivision operator to given polygon
- Each iteration
  - Increase number of vertices (approximately) * 2
- Initial polygon - control polygon
- Central questions:
  - Convergence: Given a subdivision operator and a control polygon, does the subdivision process converge?
  - Smoothness: Does subdivision converge to smooth curve?

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Subdivision schemes for surfaces

- Each iteration
  - Subdivision refines *control net* (mesh)
  - Increase number of vertices (approximately) * 4
- Mesh vertices converge to limit surface
- Every subdivision method has:
  - Method to generate net topology
  - rules to calculate location of new vertices

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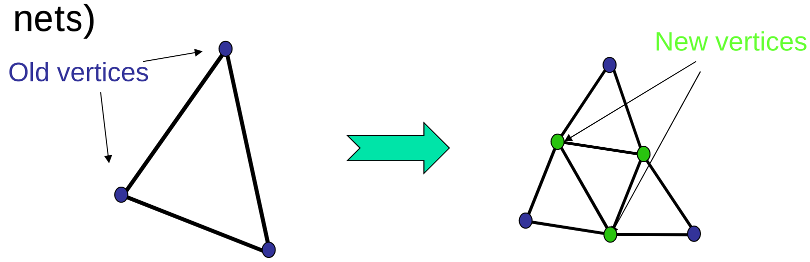
Triangular subdivision

- Works only for triangular meshes (control nets)



- Every face replaced by 4 new triangular faces
- Two kinds of new vertices:
  - Green vertices are associated with old edges
  - Blue vertices are associated with old vertices

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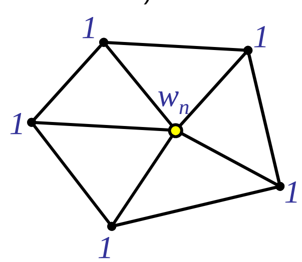
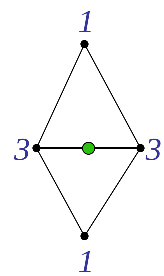
Loop's scheme

- New vertex = weighted average of old vertices
- List of weights - subdivision mask or stencil
  - Rule for new blue vertices (n – vertex valence)
  - Rule for new green vertices





$$w_n = \frac{64n}{40 - (3 + 2\cos(2\pi/n))^2} - n$$

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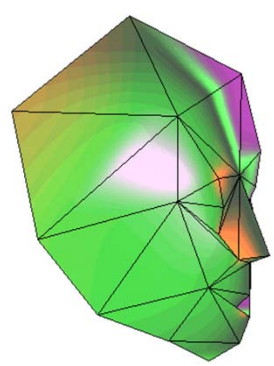
The original control net



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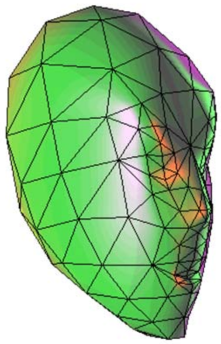
After 1st iteration



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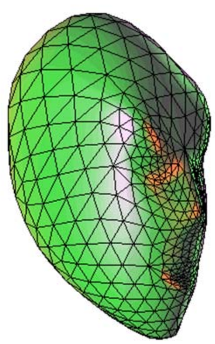
After 2nd iteration



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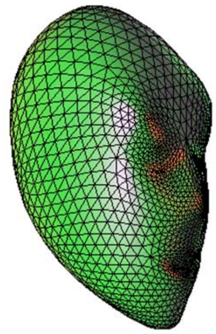
After 3rd iteration



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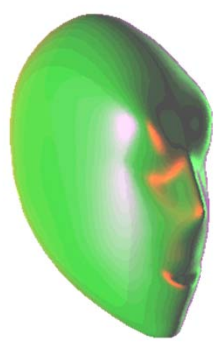
The limit surface



- Limit surfaces of Loop's subdivision is C^2 almost everywhere

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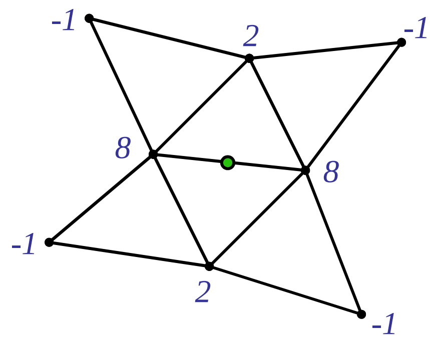
Butterfly scheme

- Interpolatory scheme
- New blue vertices inherit location of old vertices
- New green vertices calculated by following stencil:



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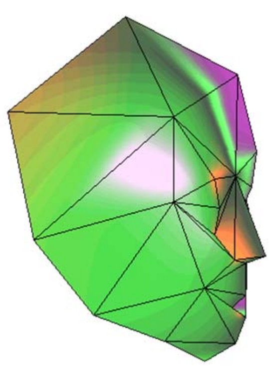
The original control net



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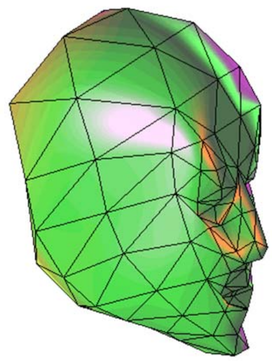
After 1st iteration



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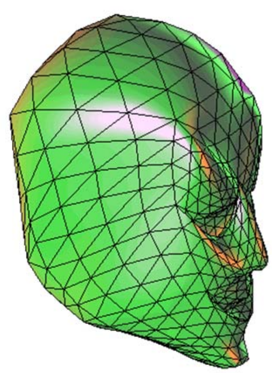
After 2nd iteration



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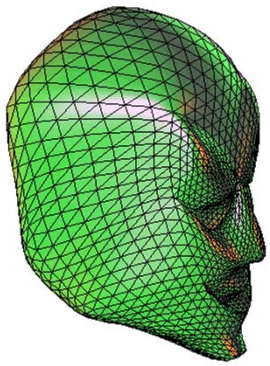
After 3rd iteration



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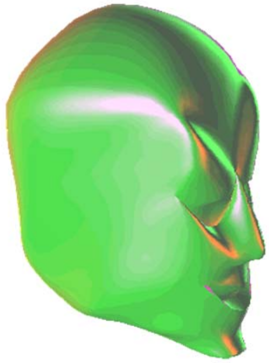
The limit surface



- Limit surfaces of Butterfly subdivision are C^1, but do not have second derivative

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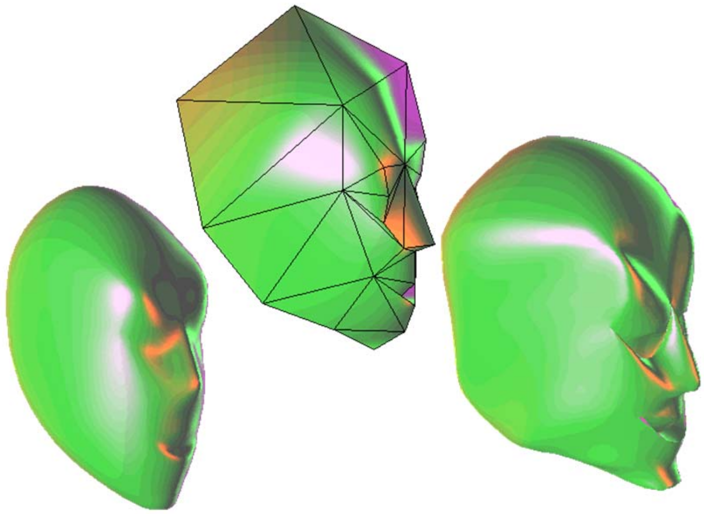
Comparison



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Properties

- Require regular connectivity (valence 6) to work well
- Easy to implement (efficiency…)
- Local support
- Allow LOD
- Continuous

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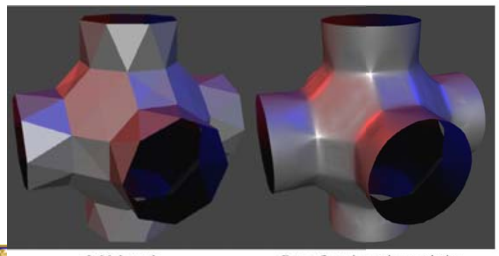
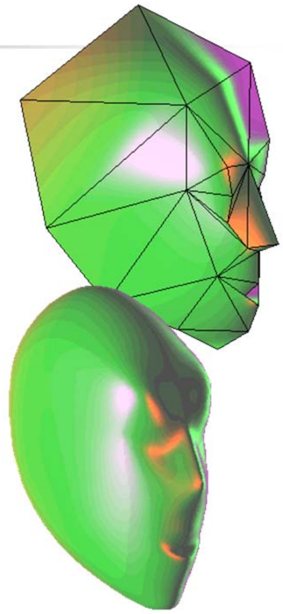
Drawbacks

- Not always intuitive
- Can have artifacts
- Hard to control



Initial mesh　　Butterfly scheme interpolation



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