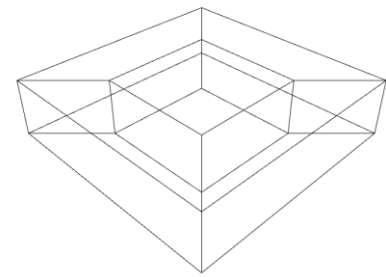


Subdivision surfaces

From theory to implementation

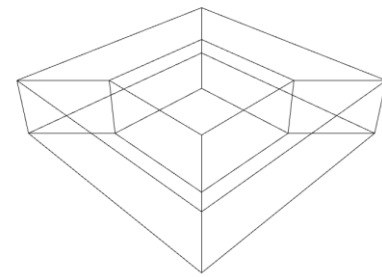
Mathieu Sanchez
Personal Inquiry
Bournemouth University

Contents

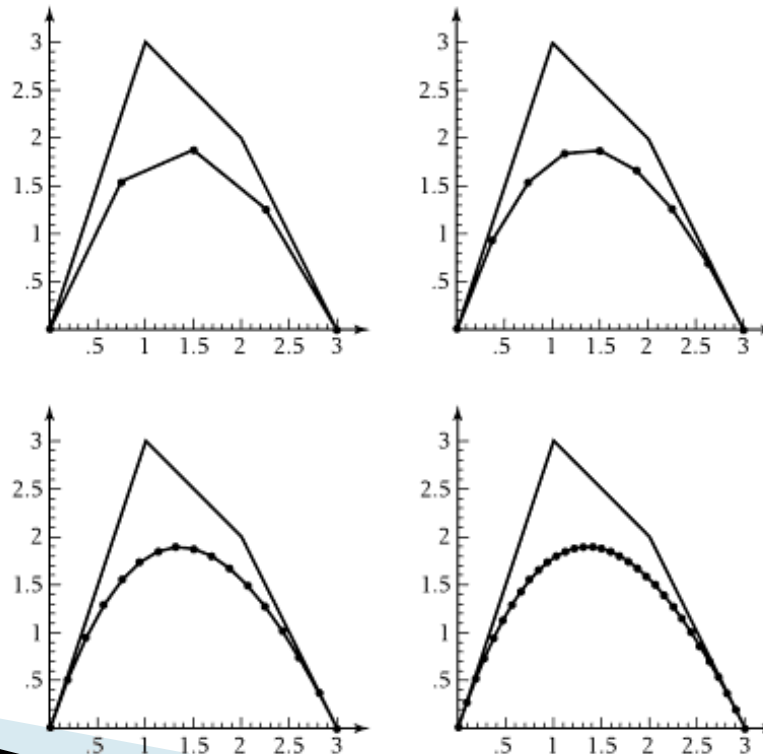


- ▶ What are subdivision surfaces?
- ▶ Why subdivision surfaces?
- ▶ Overview
- ▶ Implementation
 - Half-edge data structure
 - Catmull-clark model
 - Open mesh
 - Crease
 - Loop

What are subdivisions ?



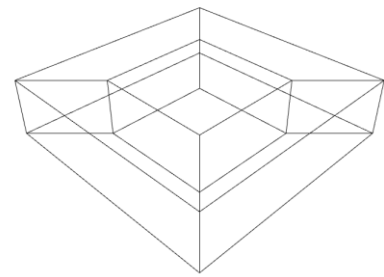
- ▶ Old but only used recently
- ▶ Smoothing
- ▶ Refinement process based on B-Splines



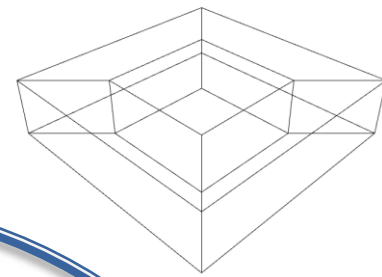
Warren, J. and
Weimer, H., 2001

Why subdivisions ?

- ▶ Surface with control mesh
- ▶ Best out of the two worlds
- ▶ Simple and efficient to implement
- ▶ Many applications



Overview



For each subdivision level

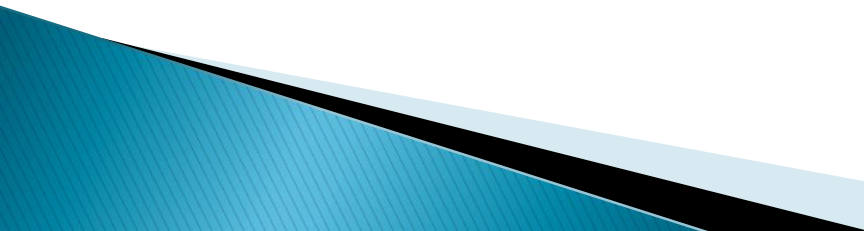
Build mesh structure

Add edge vertices

Add face vertices *

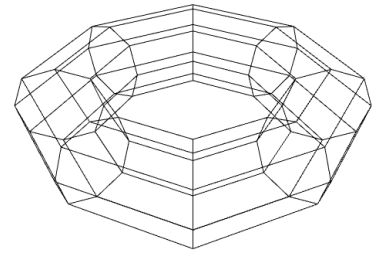
Move original *

Re-indexation

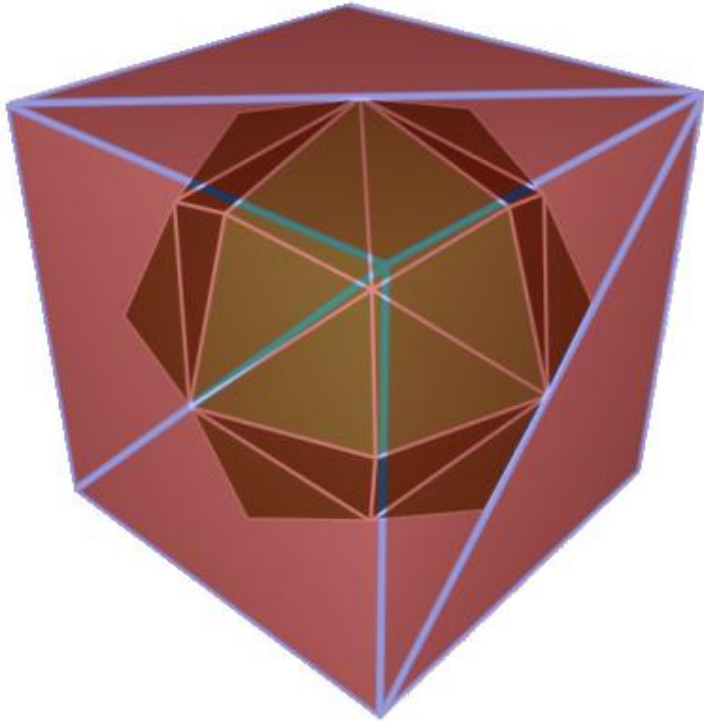
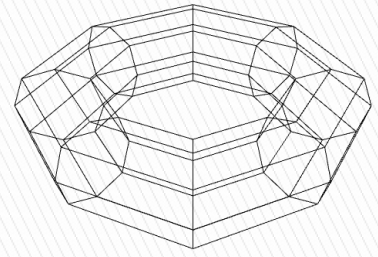


Popular schemes

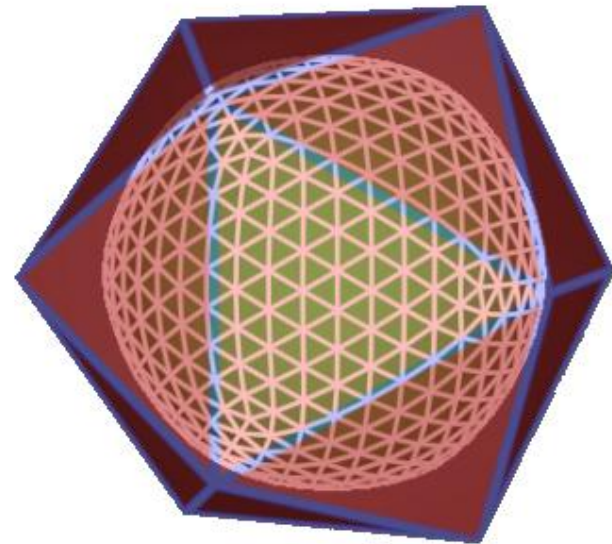
- ▶ Catmull-clark
- ▶ Doo-Sabin
- ▶ Loop
- ▶ Butterfly



Chosen schemes

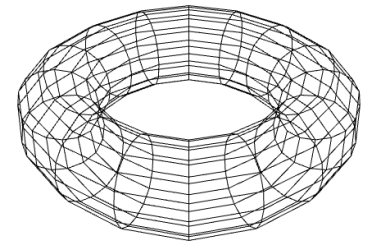


Catmull-Clark



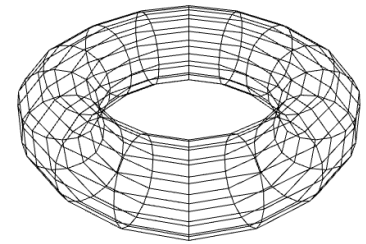
Loop

Half-Edge data structure

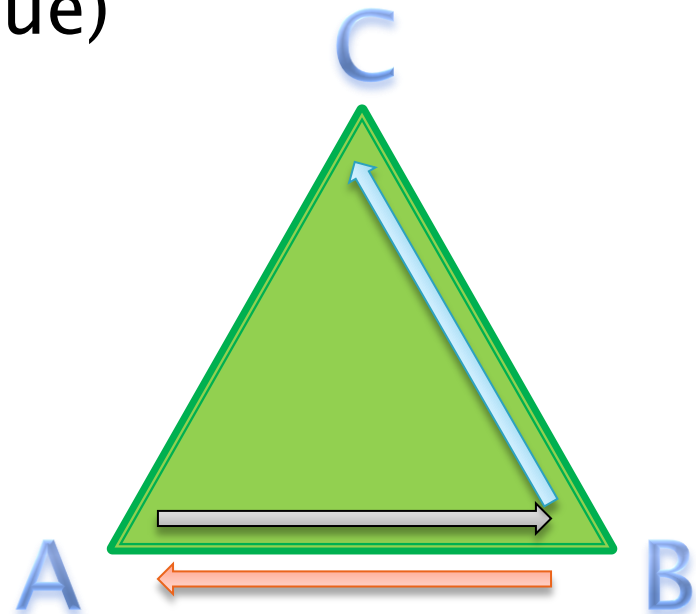


- ▶ Many neighbourhood queries
- ▶ Needed queries
 - Adjacent faces to a vertex
 - Adjacent vertices to a vertex
 - Edges and faces
- ▶ Issues and alternatives?

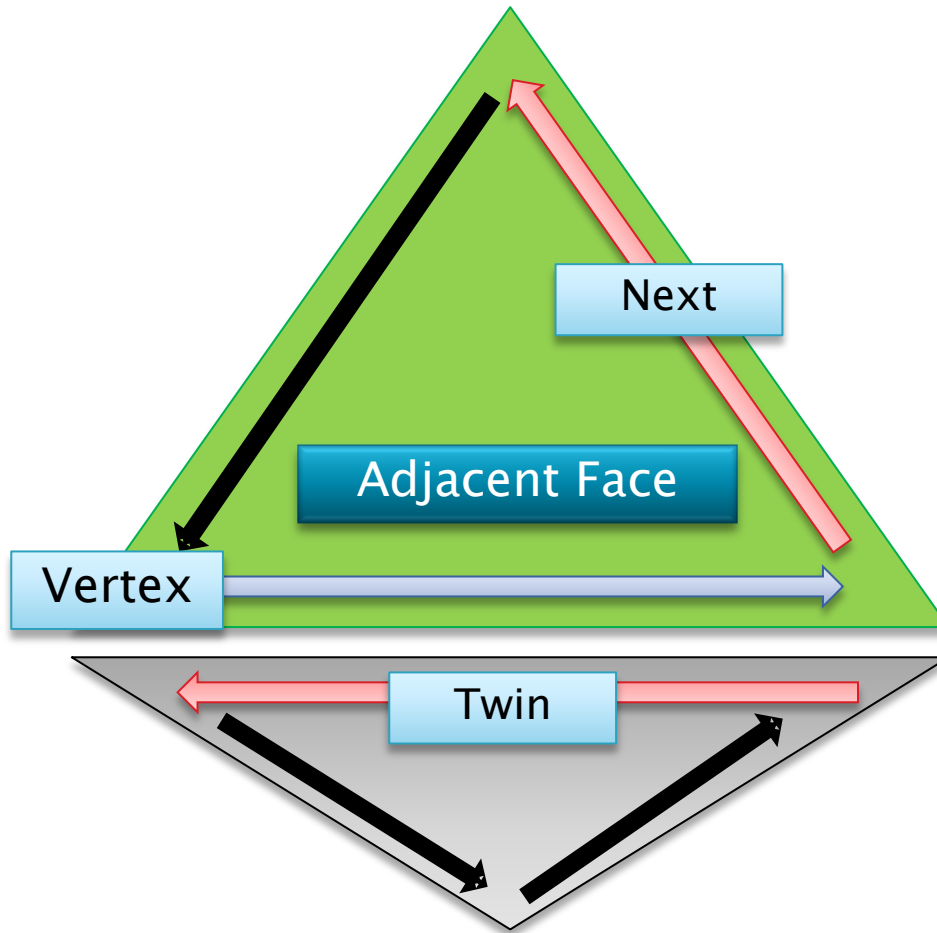
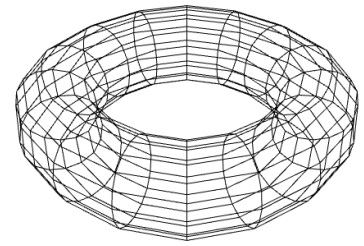
An half-edge



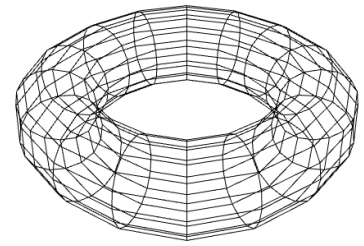
- ▶ Half-edge from A to B (black)
- ▶ Its twin - from B to A (red)
- ▶ Its base, A
- ▶ Its next - from B to C (blue)
- ▶ Parent face (green)



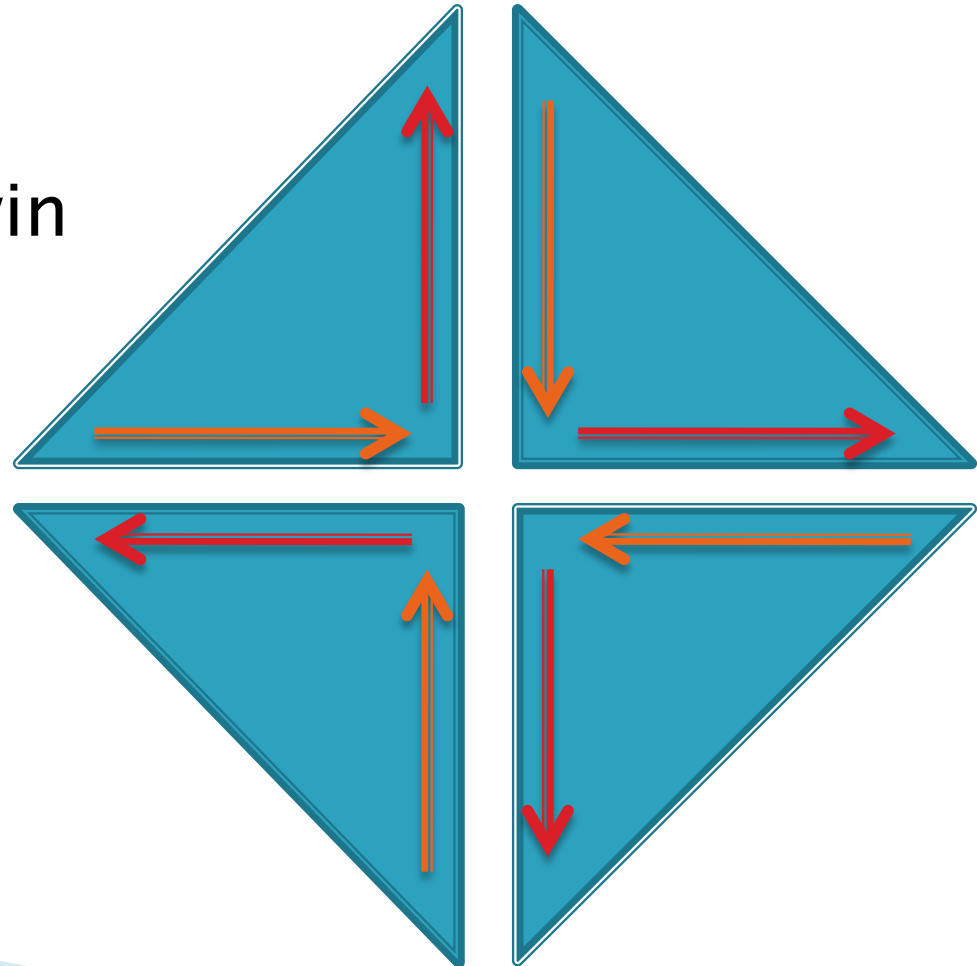
An half-edge



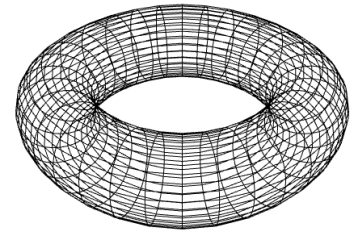
Adjacent queries



- ▶ Loop through edges around vertex
- ▶ Next's vertex
- ▶ Edge's parent face
- ▶ Next edge, next's twin



Catmull-Clark mask

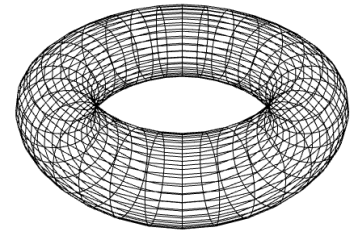


- ▶ Introduced by Pixar
- ▶ Most popular for many reasons

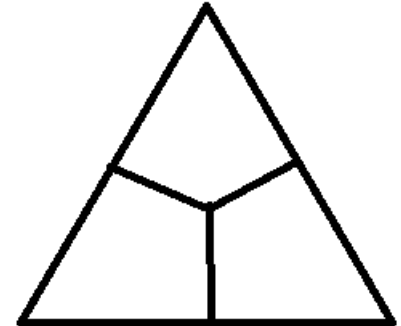
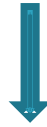
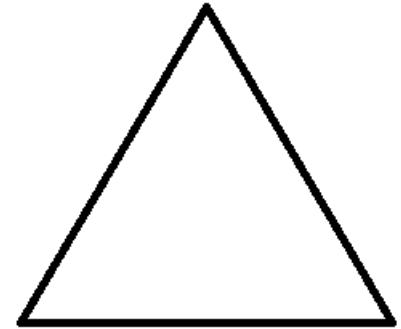
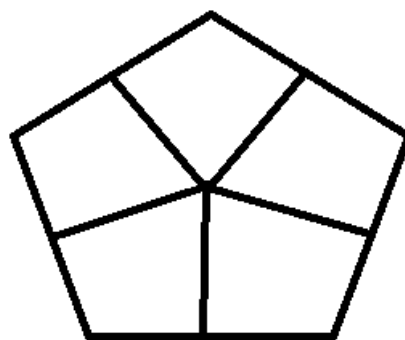
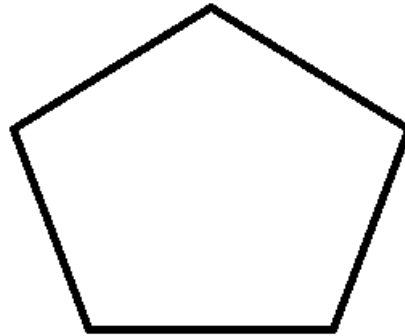
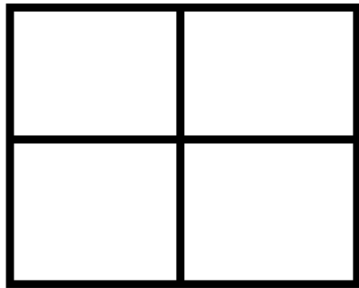


Geri's game, 1997. Pixar.

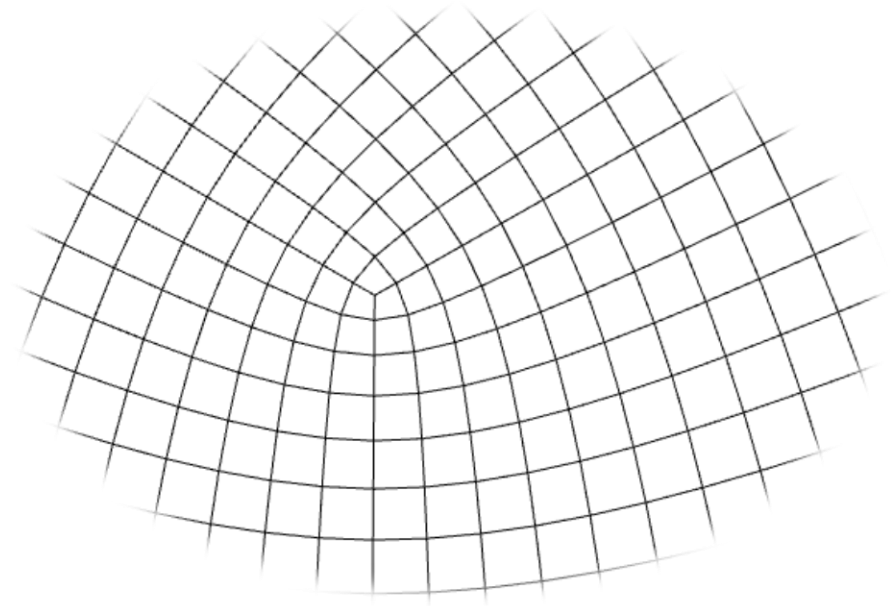
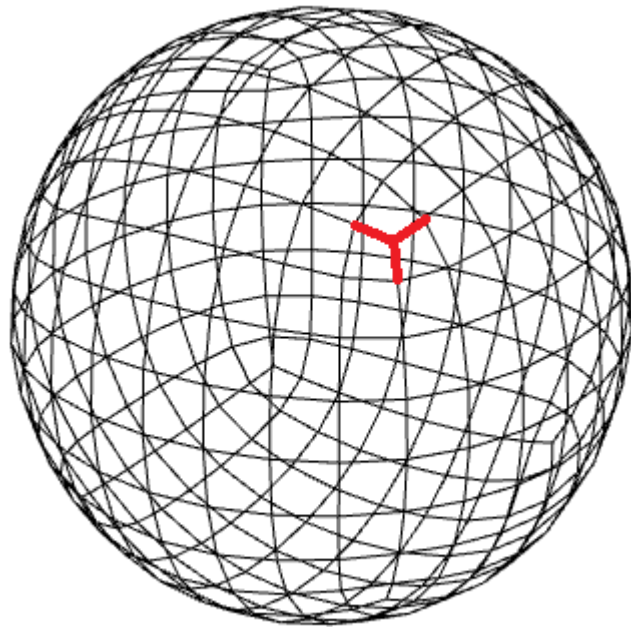
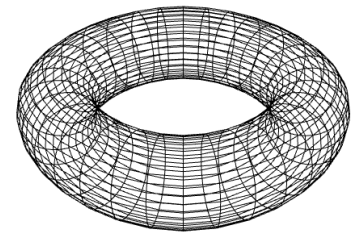
Primal Quadrateral Quadrisection



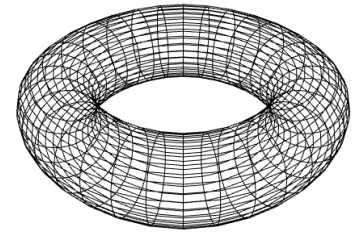
- ▶ Divides polygons into quads
- ▶ Favours quads



Extra-ordinary vertices

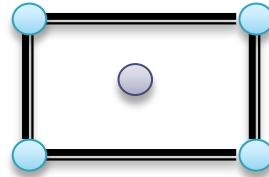


Catmull-clark mask



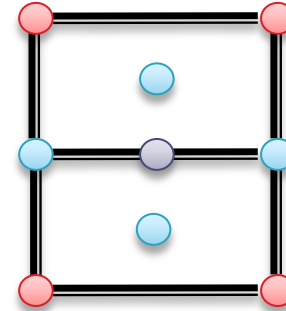
- ▶ Face vertex

- Centroid of face



- ▶ Edge vertex

- Average of edge ends and adjacent face centroids

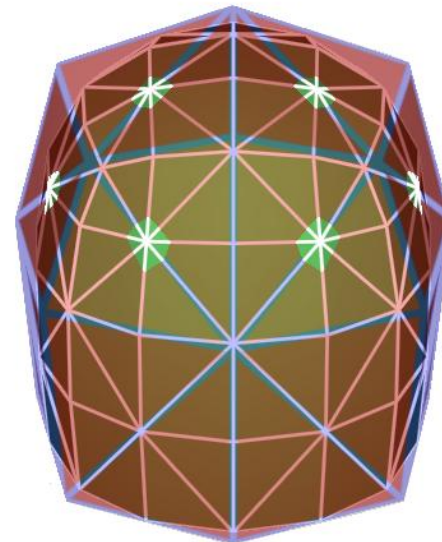
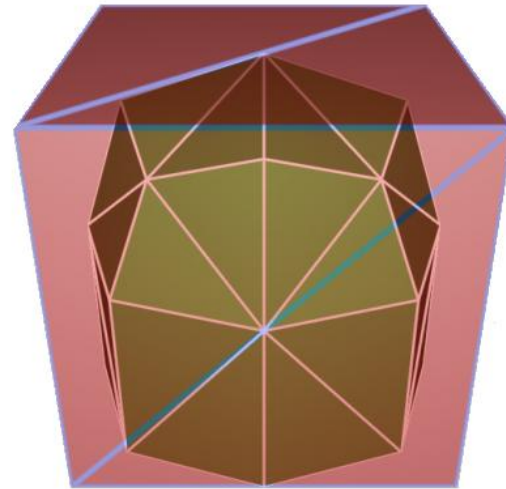
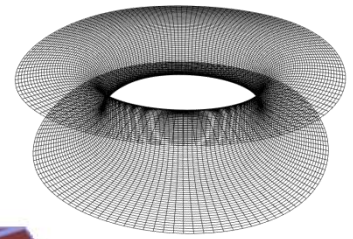


- ▶ Original vertex

- $$V_{i+1} = \frac{-F_{i+1} + 4E_{i+1} + (n-3)V_i}{n}$$

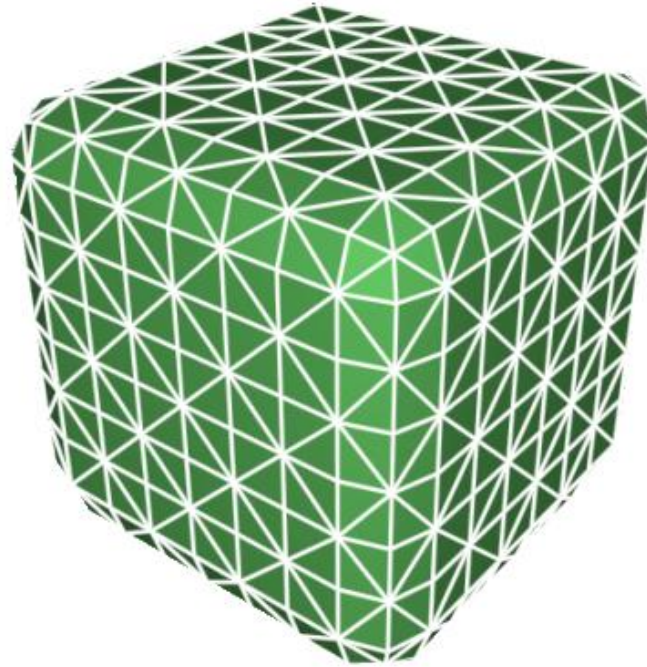
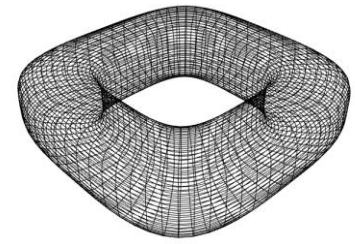
Open mesh

- ▶ Boundary rules
- ▶ Edge vertex
 - Middle of the edge
- ▶ Original vertex
 - Boundary edge vertices
 - Original vertex

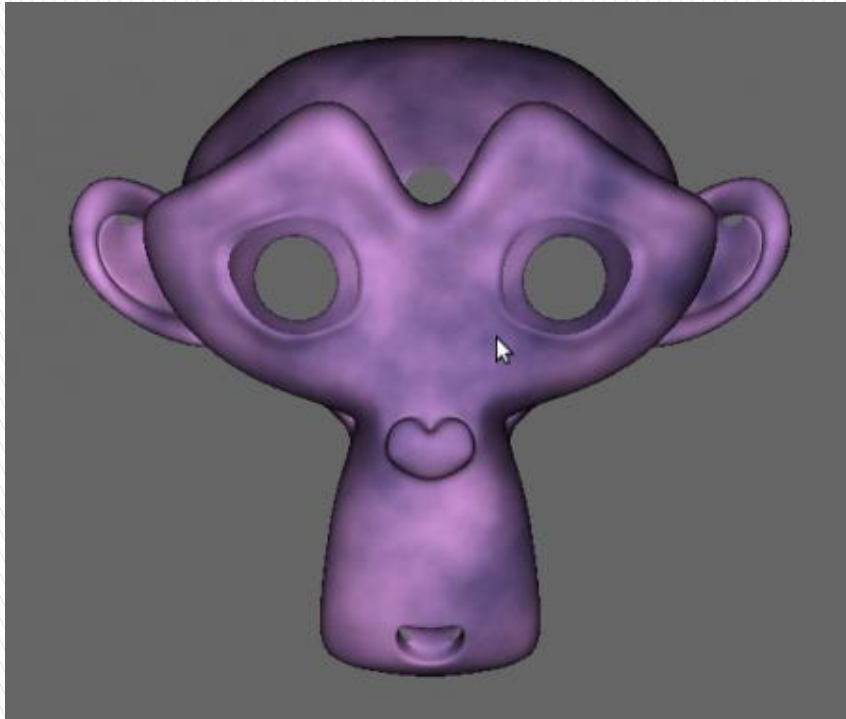
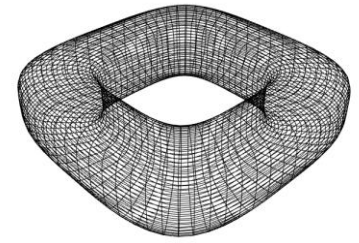


Crease

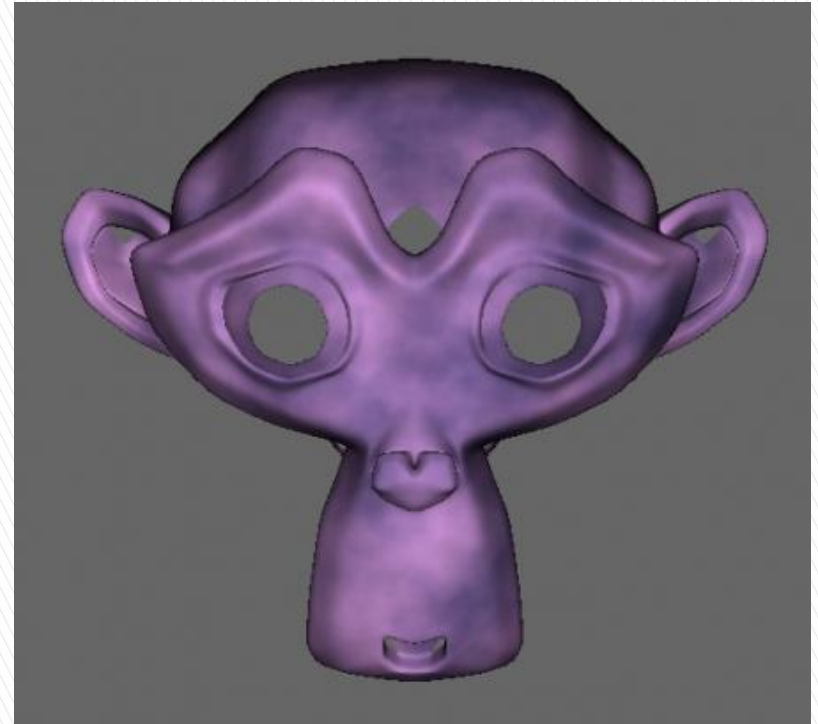
- ▶ Ruins many features
- ▶ Freeze edge/vertex



Crease comparison

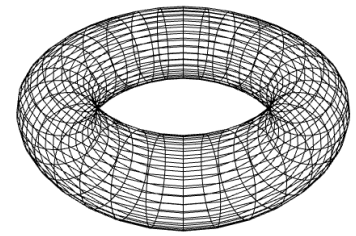


No crease

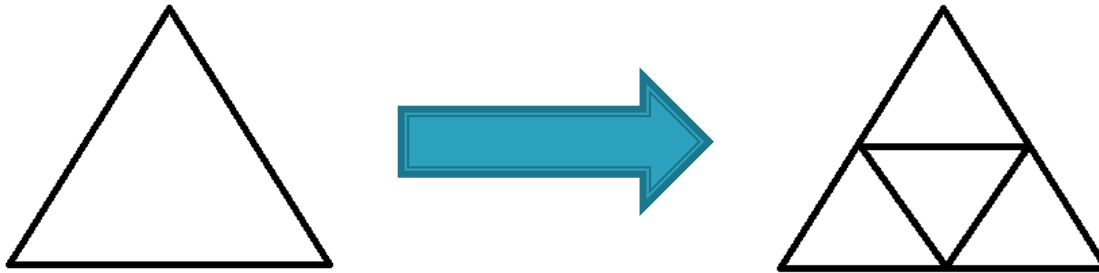


Crease level 1

Loop

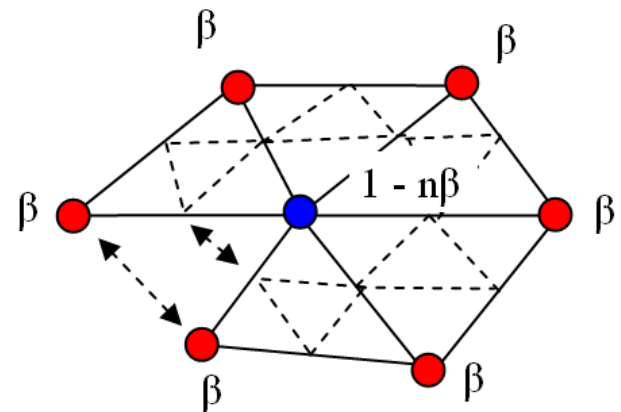


- ▶ Primal Triangle Quadrisection (PTQ)

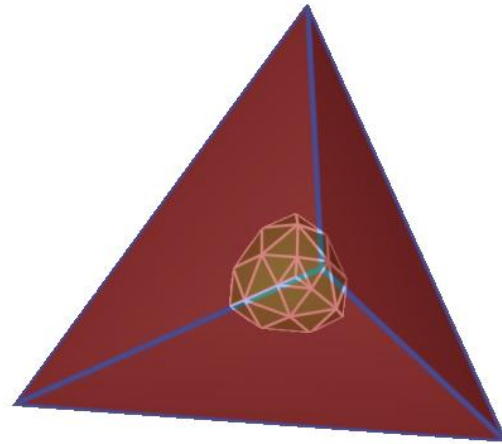
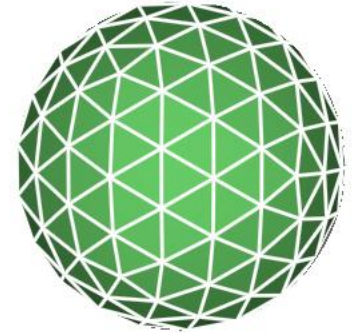
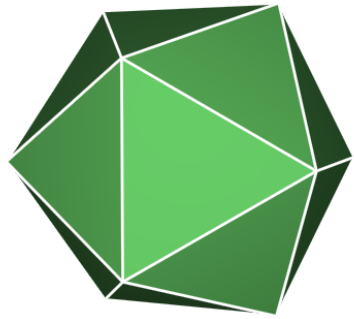
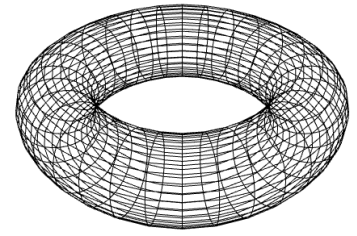


- ▶ Edge vertex
 - Average of edge and adjacent faces
- ▶ Original vertex

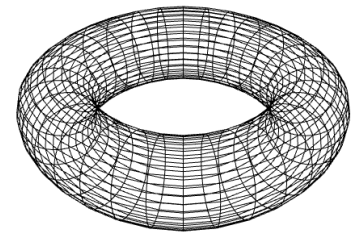
$$\beta = \begin{cases} \frac{3}{8n} & n > 3 \\ \frac{3}{16} & n = 3 \end{cases}$$



Loop results



References



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- ▶ Sharp, B., 2000, Subdivision Surface Theory.
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- ▶ Warren, J. And Weimer, H., 2001. Subdivision Methods for Geometric Design: A Constructive Approach. Morgan Kaufmann. Zorin, D., Schroder, P., DeRose, T., Kobbelt, L., Levin, A. And Sweldens, W., 2000. SIGGRAPH 2000 – Subdivision for Modeling and Animation online course notes.