Computer-Generated Medical, Technical, and Scientific Illustration

SIGGRAPH 2005

Course #31

Half-Day, Tuesday, 2 August, 8:30 am - 12:15 pm
Level: Intermediate

Computer-Generated Medical, Technical, and Scientific Illustration

Co-Organizers

- David S. Ebert
  Purdue University
- Mario Costa Sousa
  University of Calgary

Lecturers

- Amy Gooch
  Northwestern University
- Don Stredney
  Ohio Supercomputer Center

Computer-Generated Medical, Technical, and Scientific Illustration

- NPR Systems for Technical and Science Subjects
  Mario Costa Sousa, 50 min (08:30 - 09:15)
- Interactive Medical Volume Illustration
  David S. Ebert, 60 min, (9:15 - 10:15)
- BREAK (10:15 - 10:30)
- Illustration: Lighting and Material Properties
  Amy Gooch, 50 min (10:30 - 11:20)
- An Illustrator's Perspective on Computer-generated Illustration Techniques
  Don Stredney, 55 min, (11:20 - 12:15)

NPR Systems for Technical and Science Subjects

Mario Costa Sousa

University of Calgary

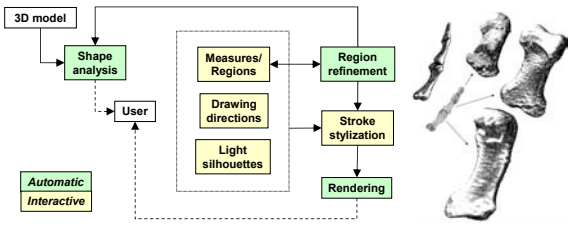
Precise Ink Drawing System

Mario Costa Sousa
Faramarz Samavati
Torin Taerum

University of Calgary

Precise Ink Drawing System

[Sousa et al 2003, 2004, Pakdel and Samavati 2004]

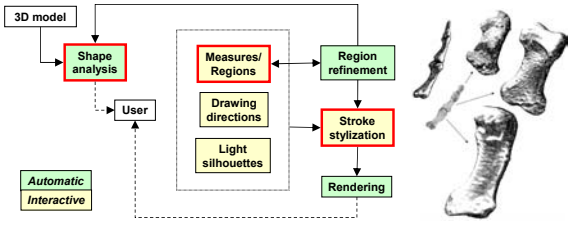


Precise Ink Drawing System

- [Sousa et al. 2003] Sousa, M., Foster, K., Wyvill, B., and Samavati, F. 2003. **Precise ink drawing of 3d models**. Computer Graphics Forum (Proc. of Eurographics '03) 22, 3, 369–379.
- [Sousa et al 2004] Sousa, M., Samavati, F., and Brunn, M. 2004. **Depicting shape features with directional strokes and spotlighting**. In Proc. of Computer Graphics International '04, 214–221.
- [Pakdel and Samavati 2004] H. R. Pakdel and F. F. Samavati, **Incremental Adaptive Loop Subdivision**, ICCSA2004. Lecture Notes in Computer Science 3045, pp. 237-246, 2004.

Precise Ink Drawing System

[Sousa et al 2003, 2004, Pakdel and Samavati 2004]



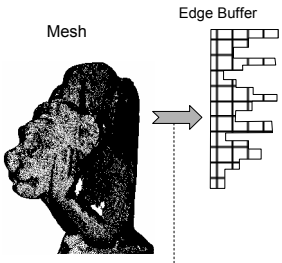
Approach

Mesh

Gargoyle, 207K Model source: Rich Pito, *University of Pennsylvania GRASP Lab*

Mesh

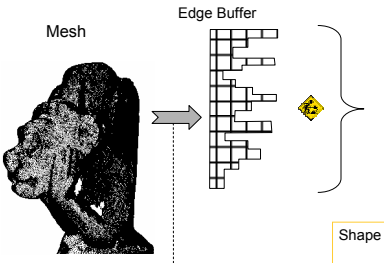
Edge Buffer



Gargoyle, 207K **Preprocess**

Mesh

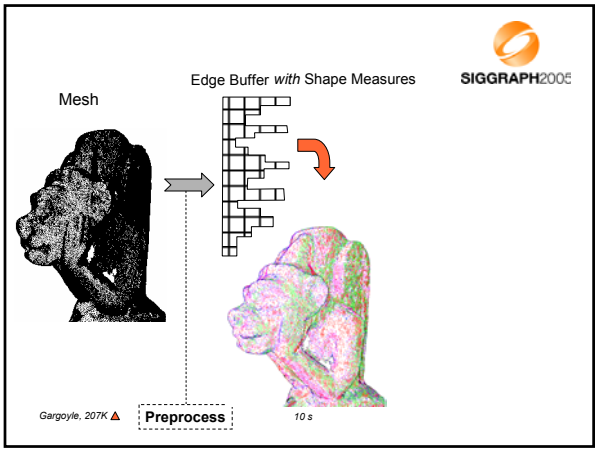
Edge Buffer

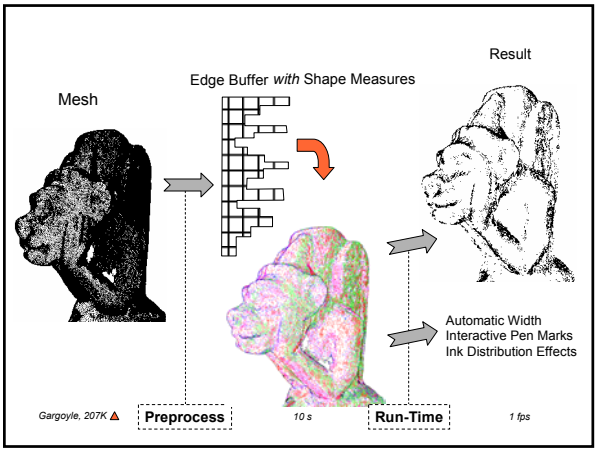


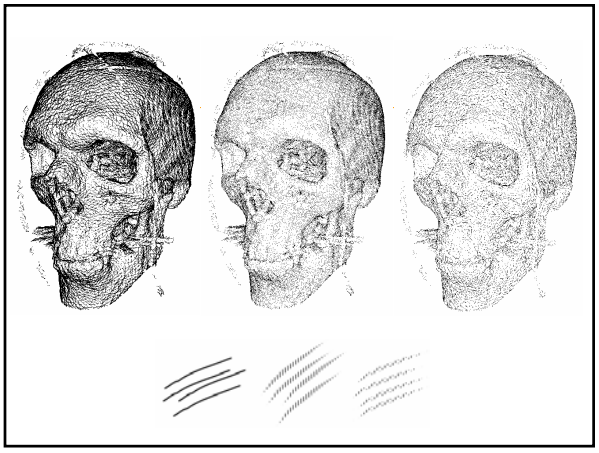
Shape Measures:

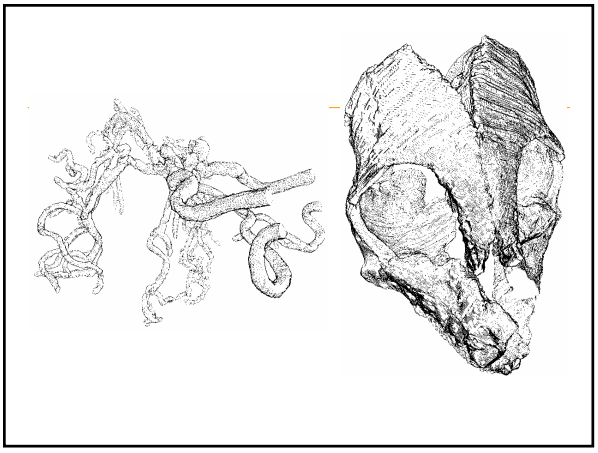
- Dihedral Angle
- Slope Steepness
- Slope Aspect
- Mean Curvature

Gargoyle, 207K **Preprocess**





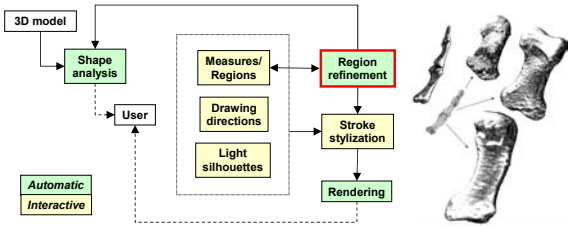




Precise Ink Drawing System

SIGGRAPH2005

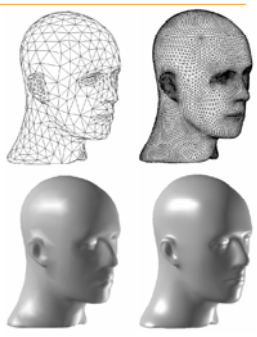
[Sousa et al 2003, 2004, Pakdel and Samavati 2004]



Adaptive Subdivision

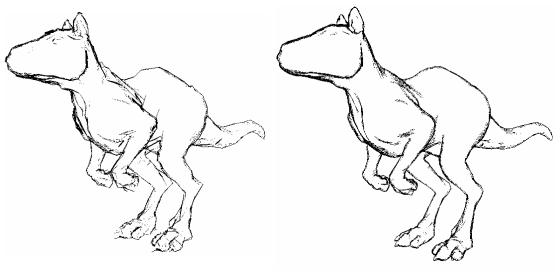
SIGGRAPH2005

- Do we really need to subdivide flat areas?
- Growth factor of faces?
- Flat area : Low curvature area



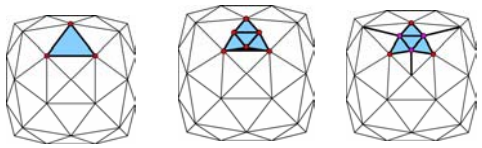
Interest based selected area

- For example: silhouette



Adaptive subdivision (Loop)

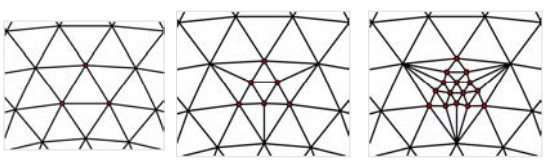
- Just subdivide and split some triangles
- Cracks !
- Solution: insert new edges (T-junctions)



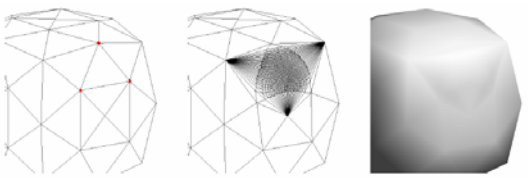
A. Amresh, G. Farin, and A. Razdan. Adaptive subdivision schemes for triangular meshes. Hierarchical and Geometric Methods in Scientific Visualization, 2003.

Repeat for several times!

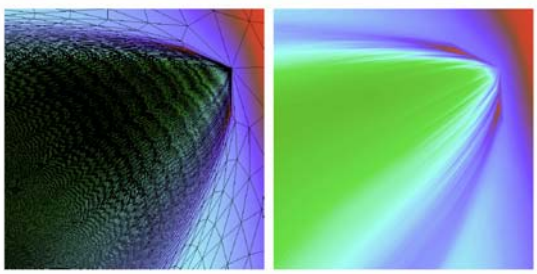
- Some “extremely” extra-ordinary vertices (O-Vertices)
- Abrupt change of the resolution



Repeat for several times!



Ripple effect

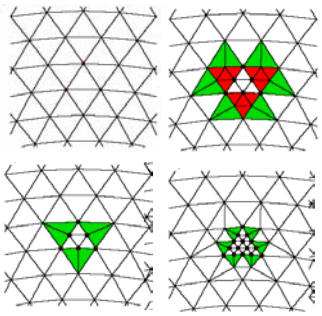


Balanced mesh: Red-Green Triangulation

- Green face: a face with one T-junctions
- Red face: a face with more than one T-Junction
- Bisect for green
- Quadrisect for red
- Complicated scheme

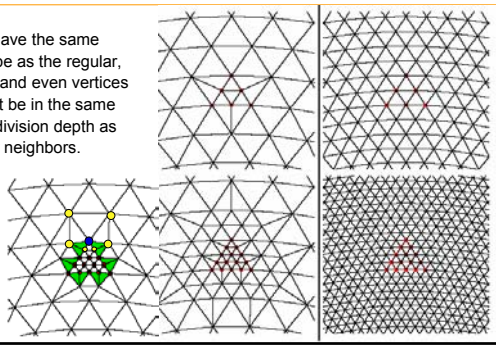
R. E. Bank, A. H. Sherman, and A. Weiser. Refinement algorithms and data structures for regular local mesh refinement. Scientific Computing, volume 1, pages 3-17, 1983.

Balanced mesh: Red-Green Triangulation

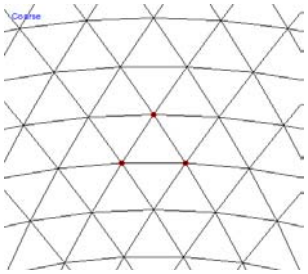


Repair of the geometry: restricted mesh

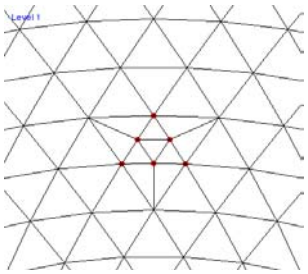
To have the same shape as the regular, odd and even vertices must be in the same subdivision depth as their neighbors.



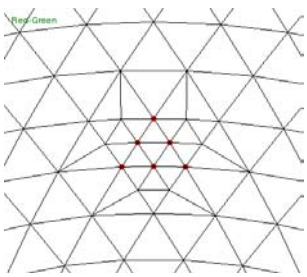
Red-Green + Restricted mesh method



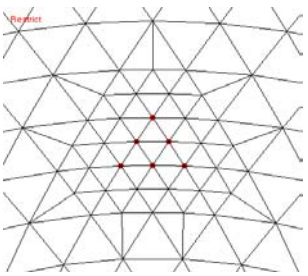
Red-Green + Restricted mesh method



Red-Green + Restricted mesh method

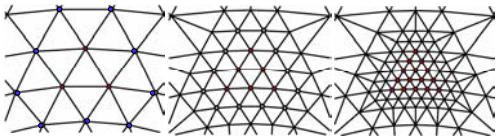


Red-Green + Restricted mesh method



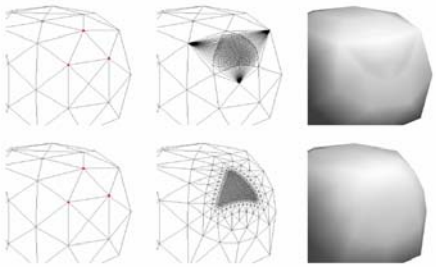
Our approach: Incremental Adaptive Loop Subdivision

- [Pakdel and Samavati 2004]
- Begin with a wider neighbourhood of the the selected area
- Use simple bisection method outside the extended area

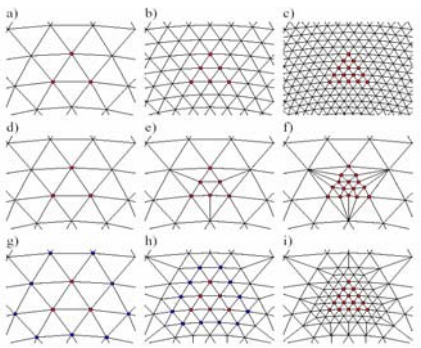


Incremental change of the resolution

Anti-aliased result

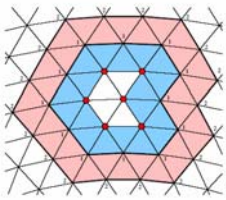


Comparison



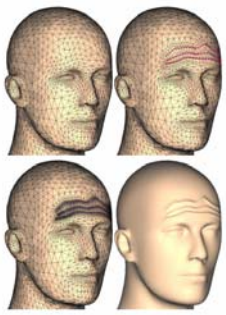
Wider extensions

- Smoother transition from coarse to fine

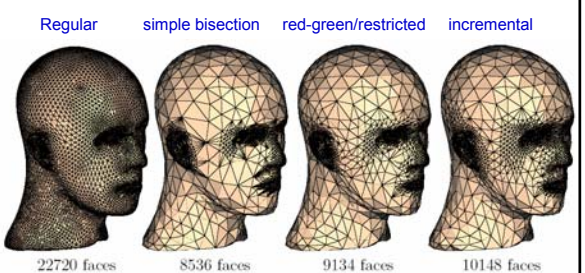


Example: sharp features

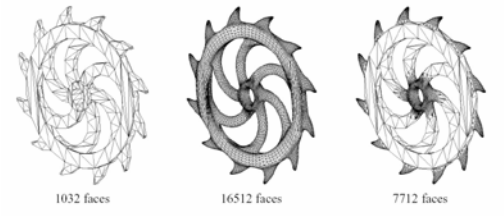
Use incremental subdivision just for creases



Example

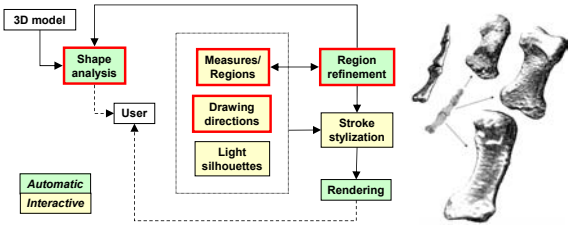


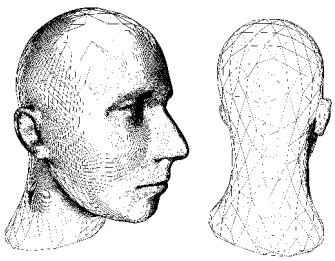
Example



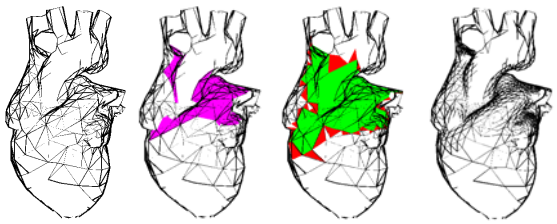
Precise Ink Drawing System

[Sousa et al 2003, 2004, Pakdel and Samavati 2004]



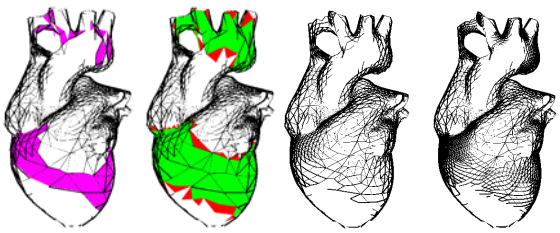


The basic idea of our approach is illustrated.
Users are able to refine the areas that they feel are important while leaving other areas unchanged.



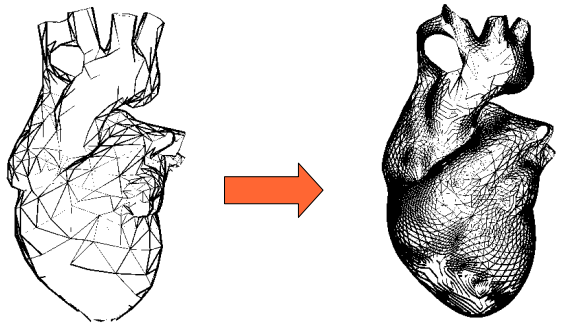
(1) (2) (3) (4)

Drawing steps session for a heart model (1619 triangles). Starting with slope steepness over the original mesh (1), the user selects threshold values for slope steepness (purple) (2), the system computes overall area to be refined (green) (3) and target triangles are subdivided with edges rendered as individual strokes (4).



(5) (6) (7) (8)

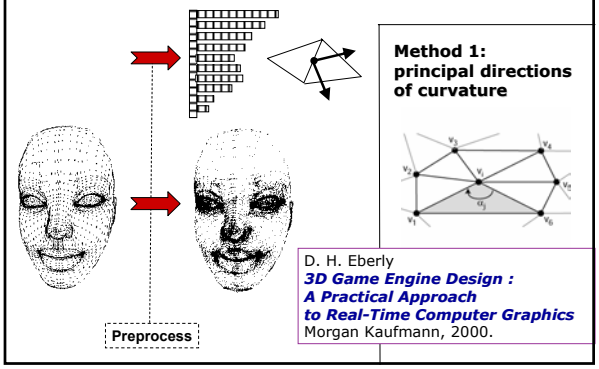
Other regions are then thresholded (5, 6), with two subsequent subdivisions and rendering (7, 8).



Original mesh

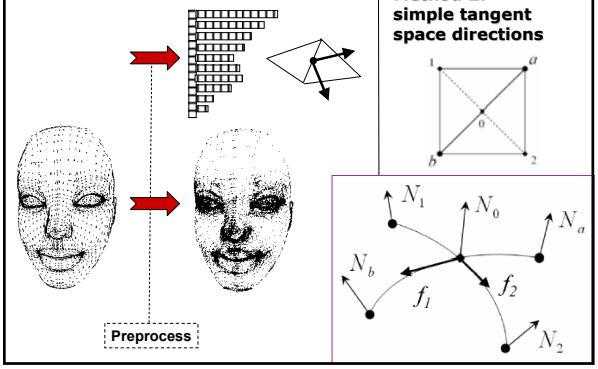
Final mesh

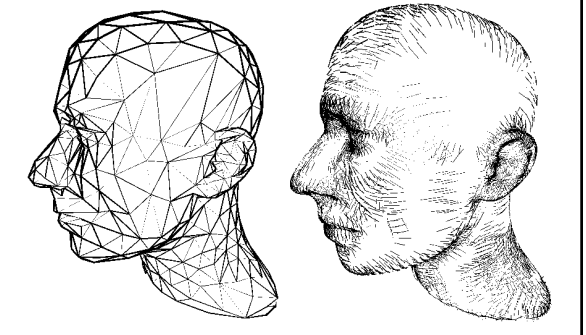
Stroke Directional Fields

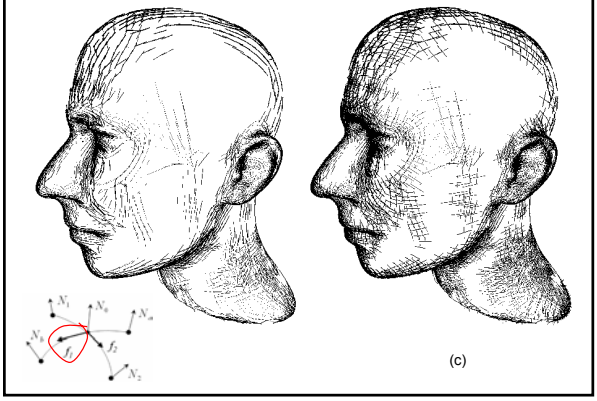


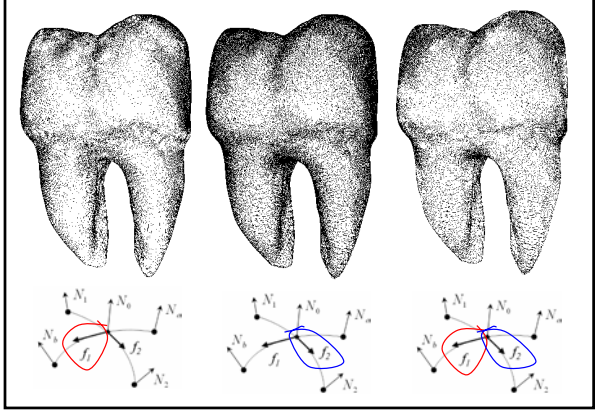
D. H. Eberly
3D Game Engine Design :
A Practical Approach
to Real-Time Computer Graphics
Morgan Kaufmann, 2000.

Stroke Directional Fields









Conclusions

SIGGRAPH2005

- Progressive refinement of 3D meshes of any given resolution at particular shape measures thresholds
- Good rendering rates
- Visual quality
- Frame coherence
- Artistic freedom
- Few parameters