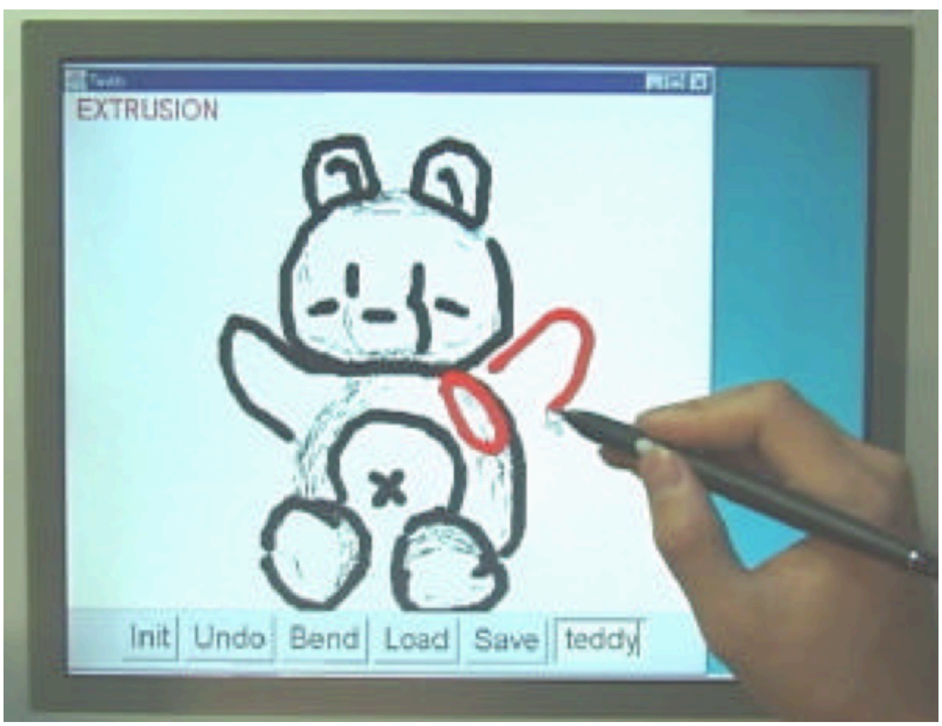
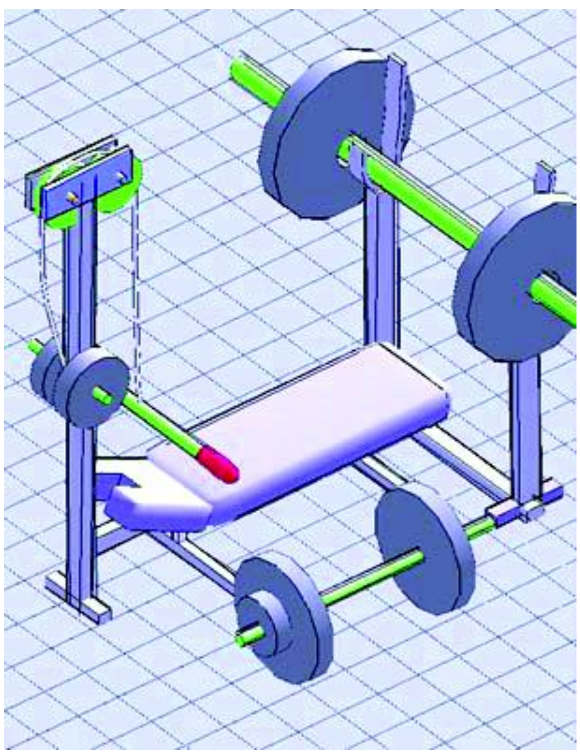
Teddy: A Sketching Interface for 3D Freeform Design

SIGGRAPH 99 paper, by Takeo Igrashi, Satoshi Matsuoka, and Hidehiko Tanaka



Motivation

- Easy to use and intuitive toolkits that animators can create a model quickly.
- E.g., SKETCH by Robert Zeleznik et al. & this paper



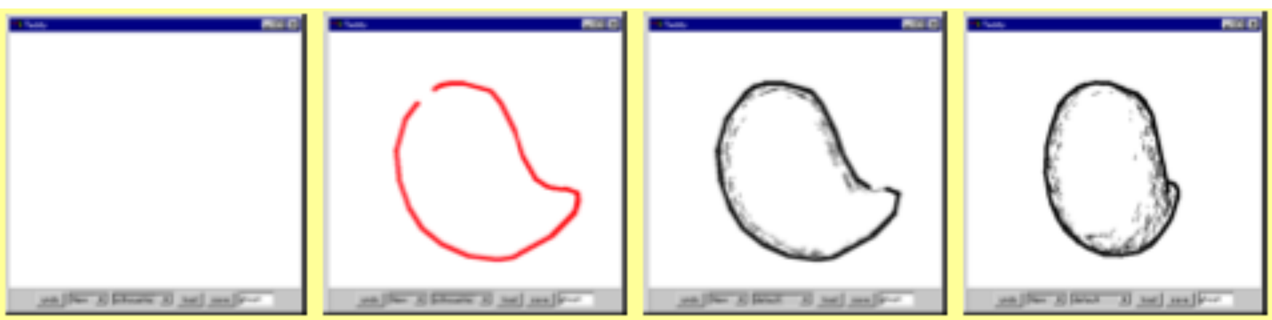
Goals

- Construction of approximate polygonal surface models
- Users can draw gestural strokes to construct objects
- Check out their video online:

http://www-ui.is.s.u-tokyo.ac.jp/~takeo/video/teddy.avi

Overview: Creating A New Object

- User draws silhouette – cannot self intersect
- Thick parts of silhouette are fat and narrow areas are skinny



a) initial state   b) input stroke   c) result of creation   d) rotated view

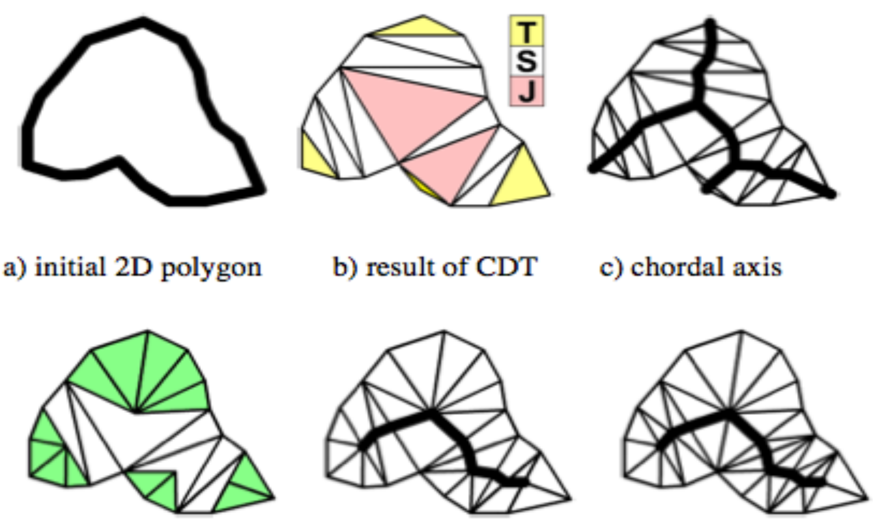
Algorithm for Creating a New Object

- The Silhouette
  - User drawn silhouette converted to line segments
  - If open, end points are joined
  - Silhouette cannot itself intersect

- Inflate the polygon
  - Construct constrained Delaunay Triangulation
  - Find chordial Axis
  - Prune insignificant branches
    - Merge triangles
    - Compute pruned spine
    - Retriangulate

Algorithm for Creating a New Object

- Inflate the polygon (details next slide)
- Find chordial Axis
- Prune insignificant branches
  - Merge triangles
  - Compute pruned spine
  - Re-triangulate

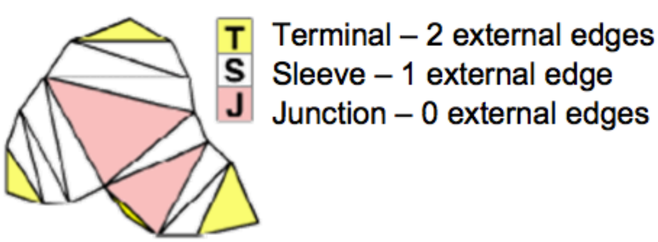


a) initial 2D polygon b) result of CDT c) chordal axis

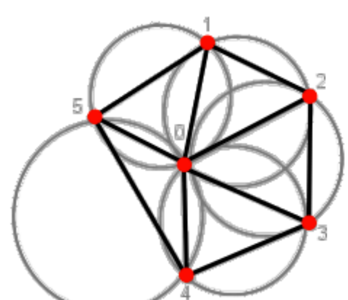
d) fan triangles e) resulting spine f) final triangulation

Algorithm for Creating a New Object

- Inflate the polygon (details next slide)
  Construct constrained Delaunay Triangulation
  - Delaunay triangulation: A triangulation such that the circumcircle of every triangle contains no other points
  - Constrained delaunay triangulation: a delaunay triangulation forced to contain edges – here the edges of the input silhouette



b) result of CDT



http://www.geoinformatik.uni-rostock.de/einzel.asp?ID=477

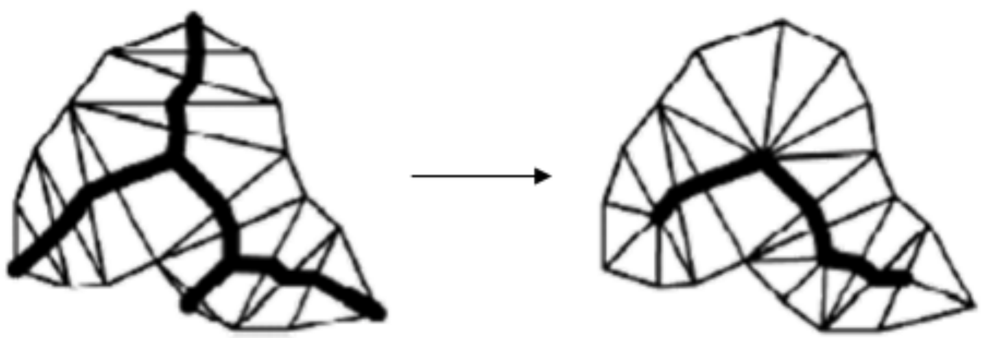
Algorithm for Creating a New Object

- Finding the Chordial Axis (Spine)
  - If open, end points are joined
  - Silhouette cannot itself intersect
  - Find the chordial axis by connecting the midpoints of the internal edges

c) chordal axis

Algorithm for Creating a New Object

- Prune insignificant branches
  - Merge triangles
  - Compute pruned spine
  - Re-triangulate



c) chordal axis e) resulting spine

Algorithm for Creating a New Object

- Prune insignificant branches
  - **Merge triangles**

    For each terminal triangle X,

    1.C: The semicircle on X's interior edge

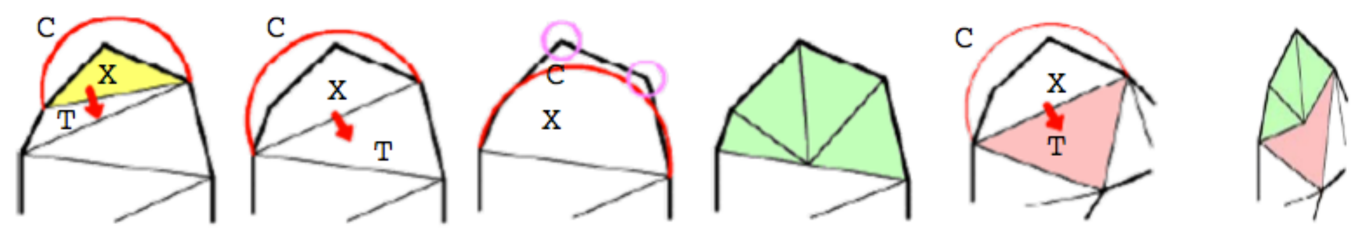
    T: the triangle sharing X's internal edge

    2. If all vertices of X are within C, merge X and T: X = X+T

    3. Else if X contains vertices not in C, make a fan of triangles from interior edge midpoint. STOP.

    4. If T in is a Junction triangle, make a fan of triangles from midpoint of T. STOP.

    5. Goto step 1.
  - Compute pruned spine
  - Re-triangulate



a) start from T-triangle b) advance c) stop d) fan triangles e) advance to J-triangle f) fan triangles at J-triangle

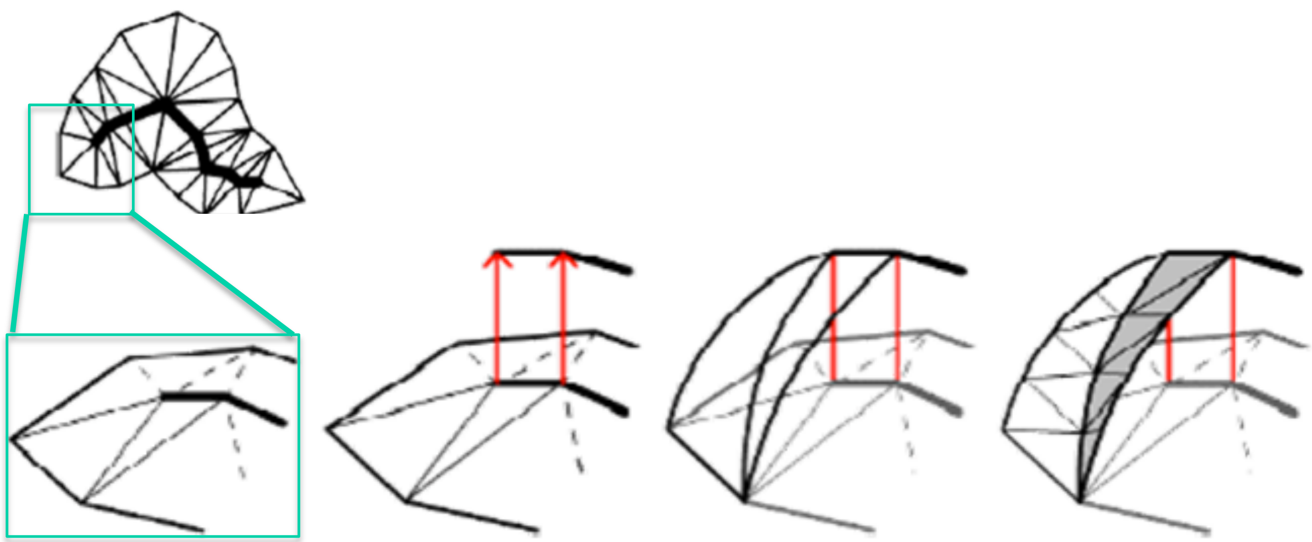
Algorithm for Creating a New Object

- Prune insignificant branches
  - **Merge triangles**
  - **Compute pruned spine**
    - **Pruned spine is obtained by connected midpoints of sleeve and junction triangles' internal edges**
  - **Re-triangulate**
    - **Divide remaining sleeve triangles at spine & re-triangulate resulting polygons**

d) fan triangles e) resulting spine f) final triangulation

Algorithm for Creating a New Object

- Elevating the Spine
  - Elevate each spine vertex by the average distance between it and its connected external vertices
  - Convert all internal edges to quarter ovals
  - Sew neighboring elevated edges



a) before b) elevate spines c) elevate edges d) sew elevated edges

Figure 15: Polygonal mesh construction.

Teddy: Painting on the Surface

- Convert input stroke to line segments
- For each line segment
  - Compute bounded plane containing segment and camera
  - Intersect plane with each polygon of surface (use closest)
  - Connect line segments on surface
- If line segments cannot be connected (i.e., painting across a fold), painting fails.

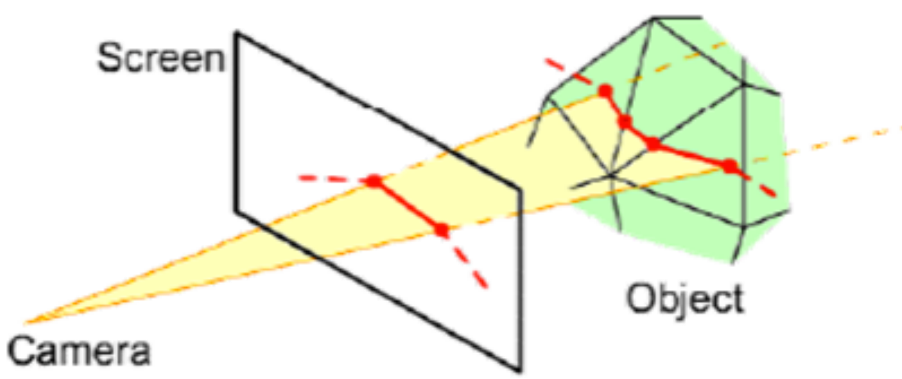


Figure 16: Construction of surface lines.

Interaction: Extrusion

- Base ring: closed polyline on mesh surface
- Normal: Best fit plane to the base ring
- Projective plane: plane through base ring center of gravity and parallel to the normal
- Project 2D extruding stroke onto plane
- Sweep base ring along extruding stroke such that
  - Base rings are almost perpendicular to the direction of the extruding stroke
  - Base rings are resized to fit extruding stroke
- Delete polygons underlying the base of the extrusion and sew extrusion to surface
- Same algorithm used for digging cavities

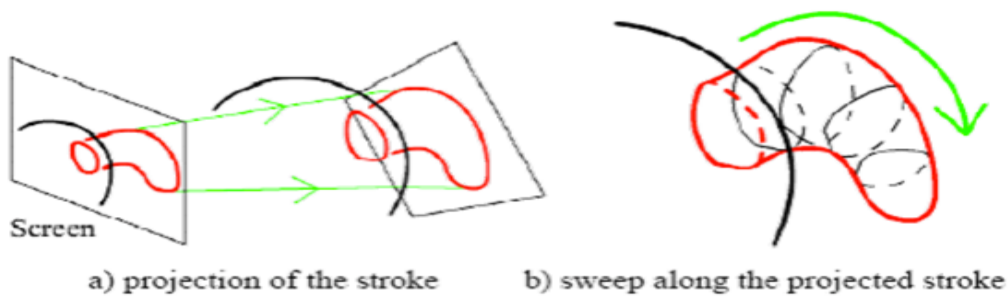


Figure 17: Extrusion algorithm.

Interaction: Cutting

- Based on painting algorithm
- For each line segment of cutting stroke
  - Project onto front and back facing polygons intersected by bounded plane
  - End points of projected segment are connected to create a planar polygon
- Splice planar polygons together
- Triangulate planar polygons
- Remove all polygons on surface to left of cutting stroke

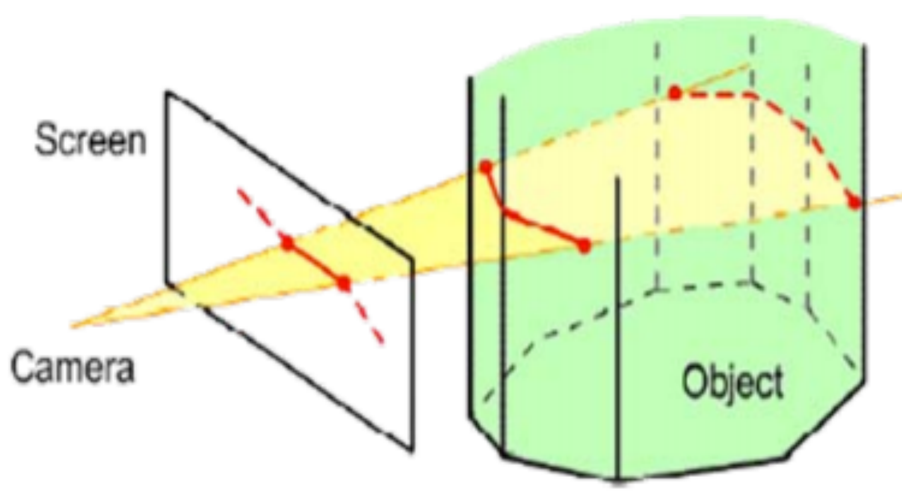


Figure 20: Cutting.

Smoothing

- Change coordinate system so that the normal of base ring is parallel to the Z-axis
- Project base ring into XY-plane and triangulate it
- Determine Z-values for vertices of triangulated base ring.
  - For each vertex
    - For each edge opposite the vertex
    1. Consider plane parallel to the Z-axis through the vertex and the mid-point of the edge
    2. Choose Z-value so that the point lies on the Bezier curve that smoothly interpolates both ends of the ring on the plane
  - The final Z-value is the average of the Z-values across all edges

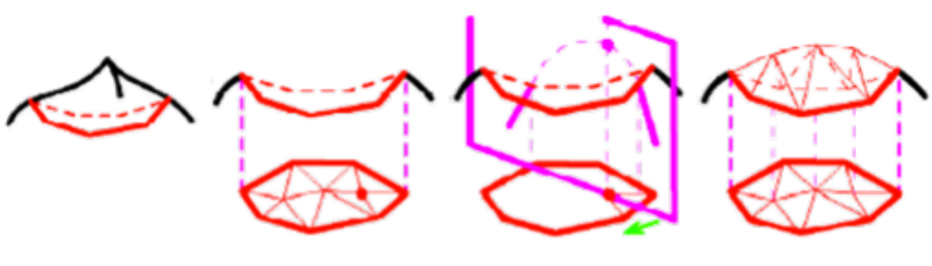


Figure 21: Smoothing algorithm.