

Teddy: A Sketching Interface for 3D Freeform Design

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Author



Outline

- Introduction
- User interface
- Modeling Operations
- Algorithm
- Result
- Conclusion

Introduction

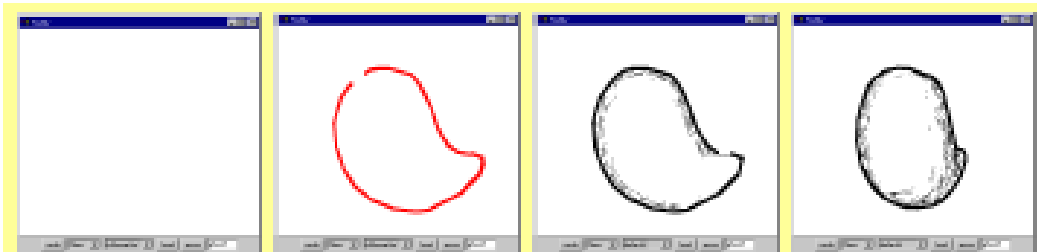
- Automated construct 3D freeform models
- Sketching Interface
 - Use 2D freeform strokes
- Easy to use
 - No control points or complicated editing operations
- Resulting Model
 - Hand-crafted feel



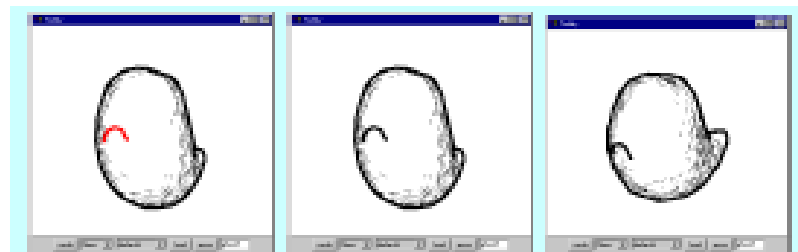
User Interface : Draw some freeform 2D strokes

Results (painted using a commercial texture-map editor)

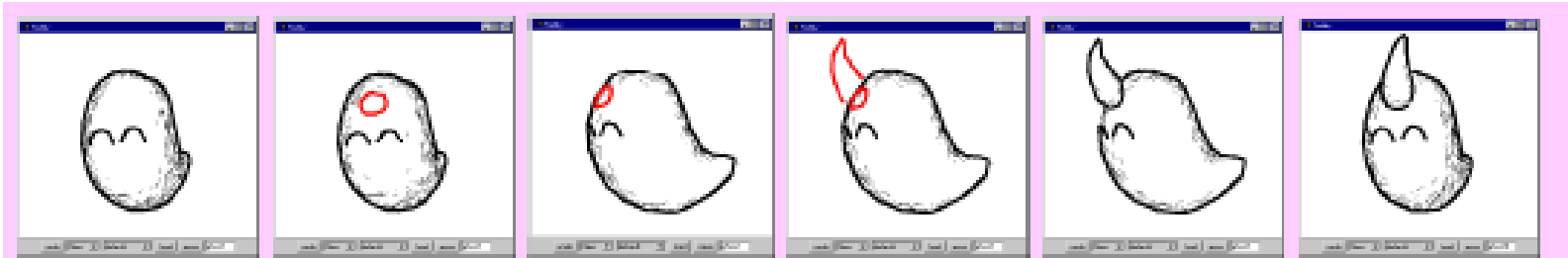




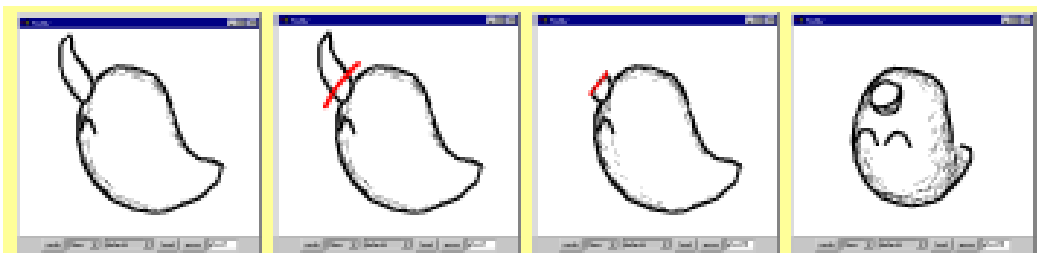
a) initial state b) input stroke c) result of creation d) rotated view



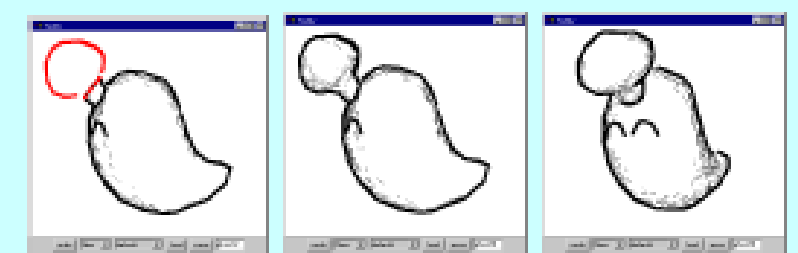
e) painting stroke f) result of painting g) rotated view



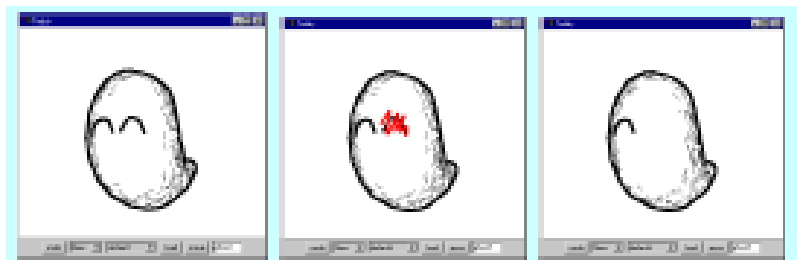
h) before extrusion i) closed stroke j) rotated view k) extruding stroke l) result of extrusion m) rotated view



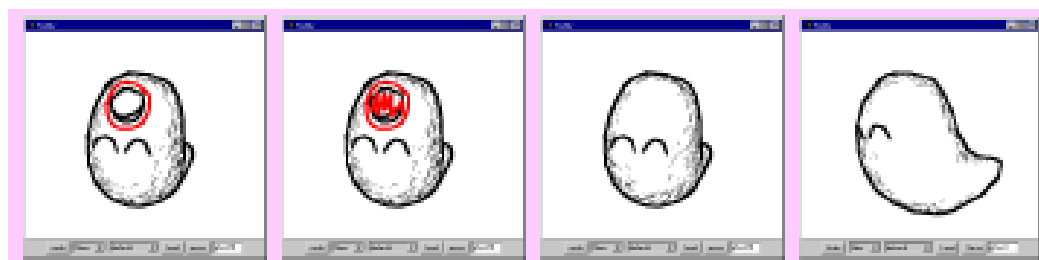
n) before cutting o) cutting stroke p) result of cutting q) result of click



r) extrusion after cutting s) result of extrusion t) rotated view

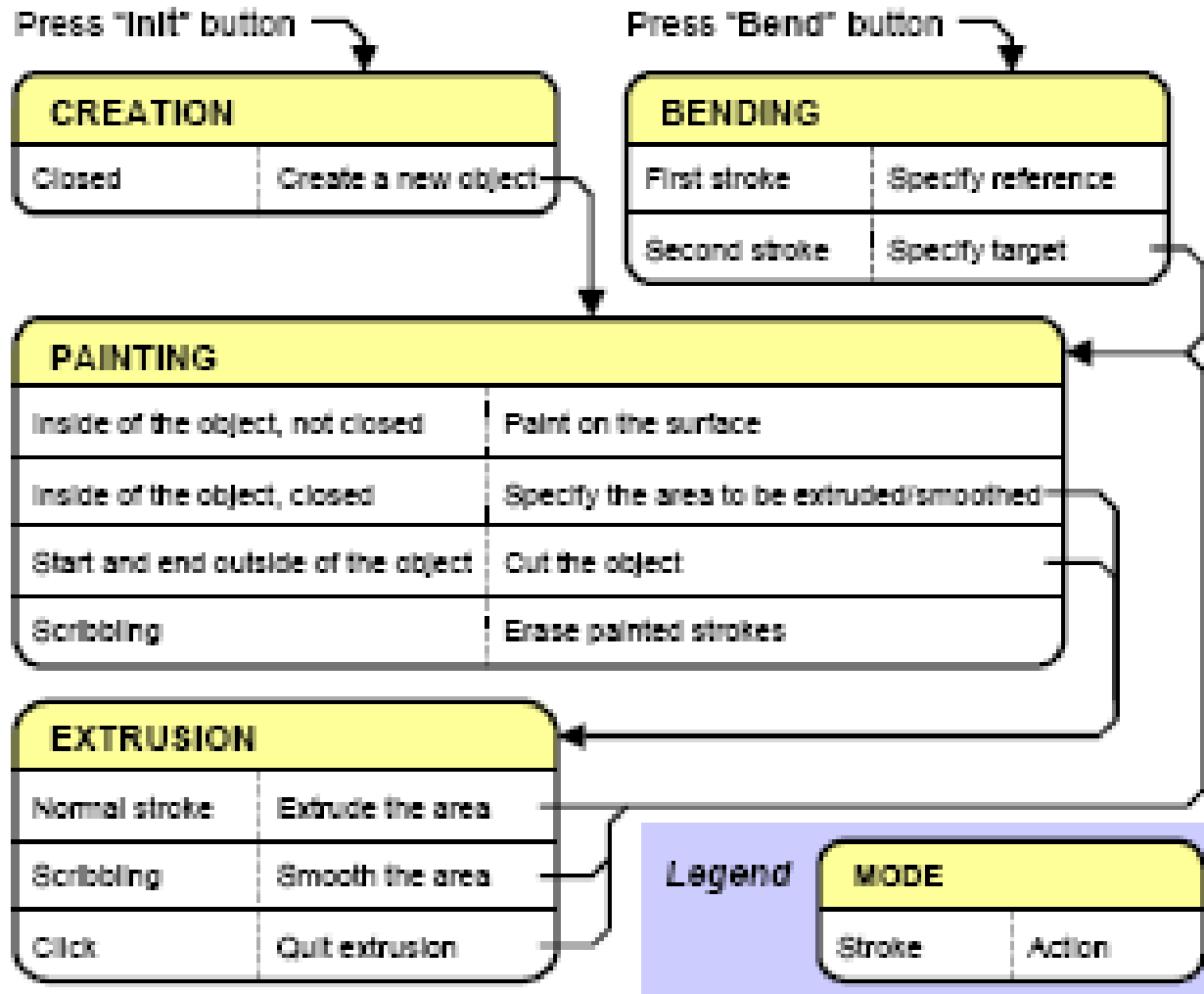


u) before erasing v) scribbling w) result of erasing



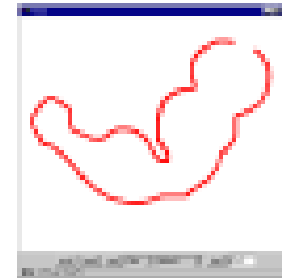
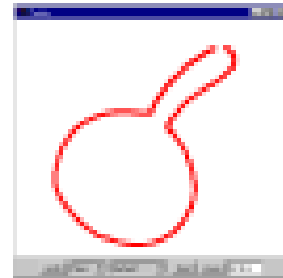
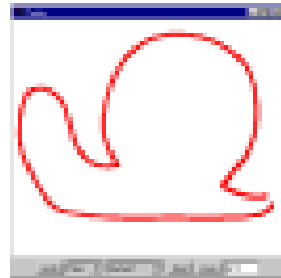
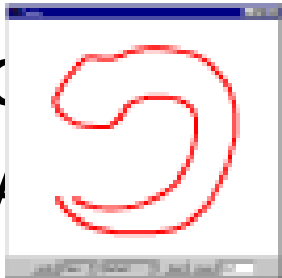
x) closed stroke y) scribbling z) result of smoothing z') rotated view

User Interface

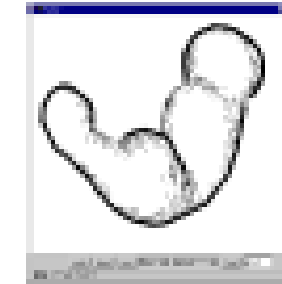
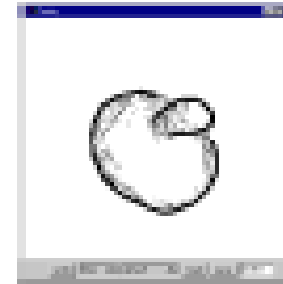
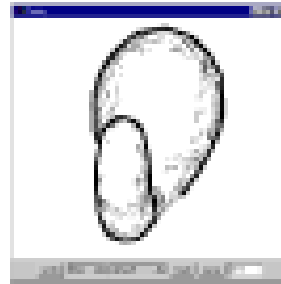


Modeling Operations -- Creating

- Close
- /
- Face
- Wire
- /



oints



a) snake

b) snail

c) cherry

d) muscular arm

Painting and Erasing

- Stroke must not cross the 2D silhouette
- Simply project onto object surface as 3D line segments
- Erase surface lines by drawing a scribbling stroke

Extrusion



a) digging stroke b) result c) rotated

d) closed stroke e) after click

d

- Mak
- Dr
- Do r



a) long

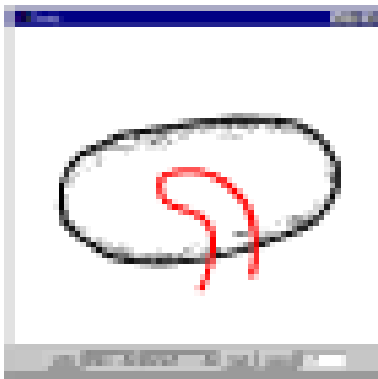
b) thin

c) fat

d) sharp

Cutting

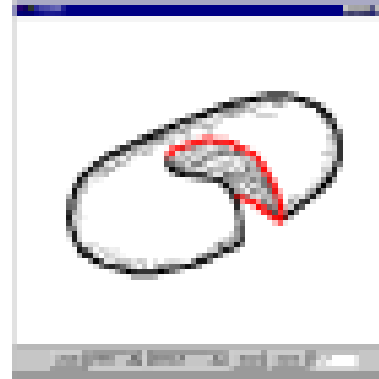
- Start outside , terminate outside
- Remove left of stroke
- 'bite' operation
- Extrusion after cutting
 - Useful to modify the shape



a) biting stroke



b) result

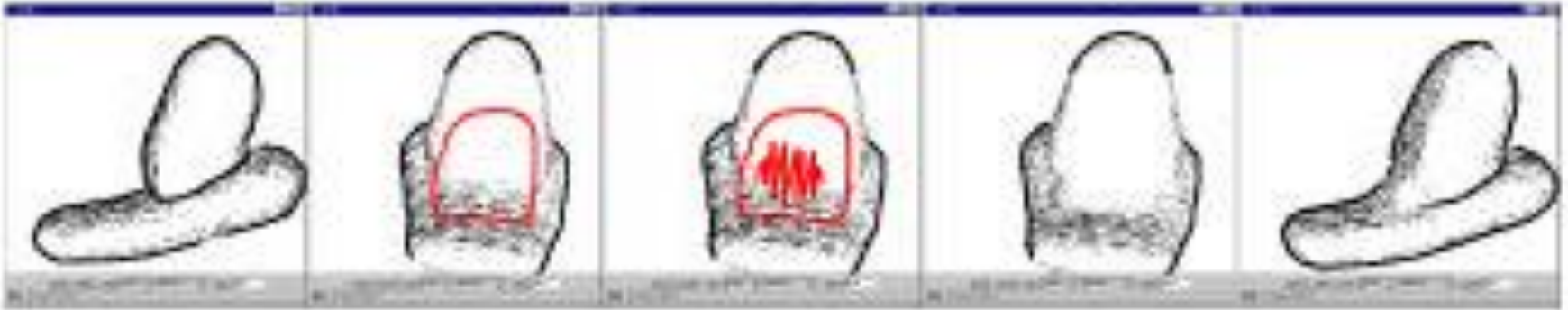


c) rotated view



d) after click

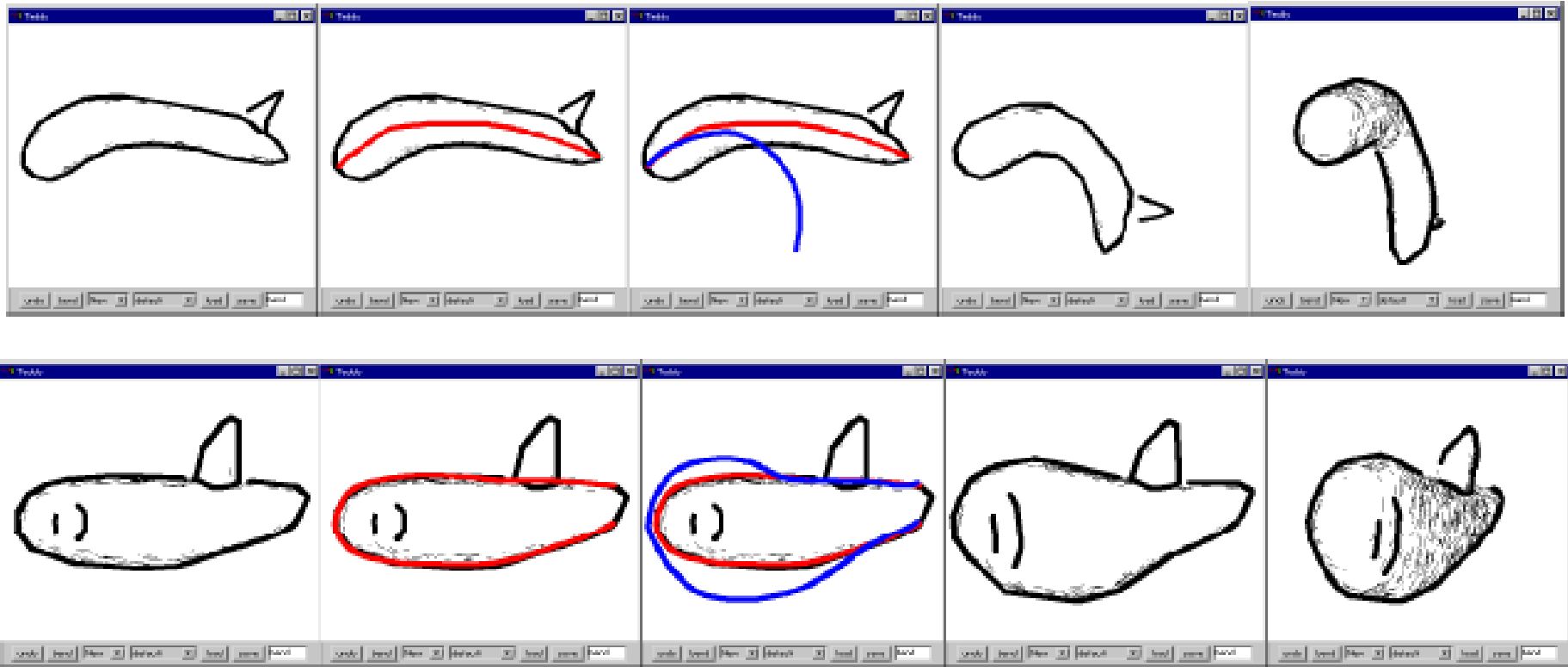
Smoothing



b) smoothing a sharp edge

- Remove bumps and cavities
- Smooth creases (often caused by extrusion operation)

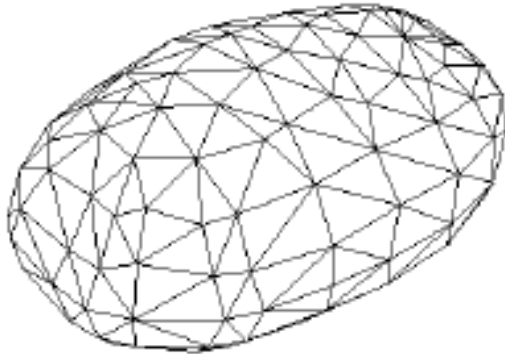
Transformation



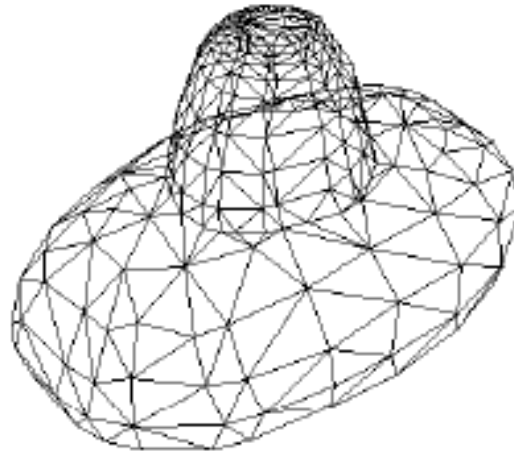
a) original b) reference stroke c) target stroke d) result e) rotated

Algorithm

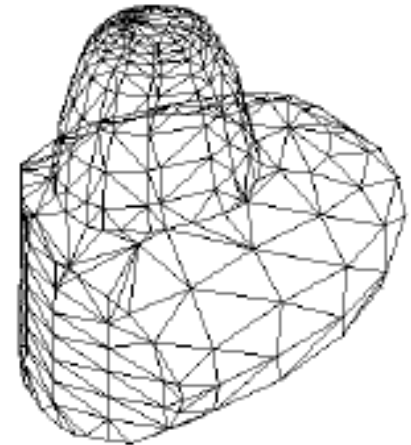
- Result model is topological equivalent to sphere
- Input stroke resampled to smooth polyline
→ remove handwriting noise



a) after creation



b) after extrusion



c) after cutting

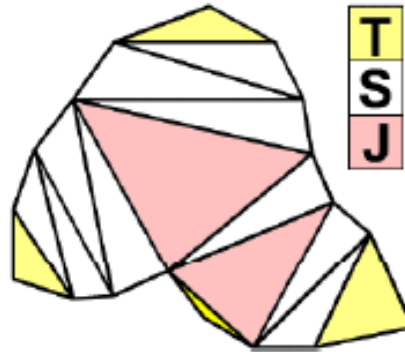
Creating a New Object

- 1. Create closed planar polygon
- 2. Find spine and Triangulation(2D)
- 3. Elevate the vertices of spine
- 4. Construct polygonal mesh

Find spine & Triangulation



a) initial 2D polygon



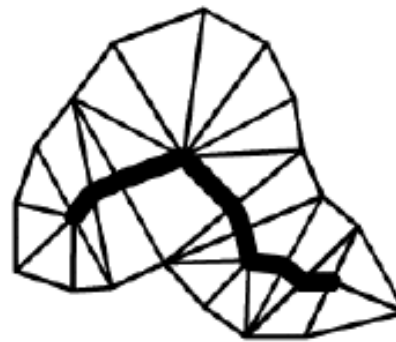
b) result of CDT



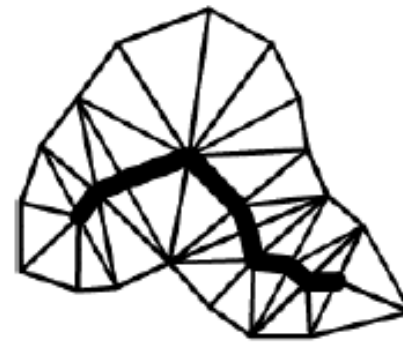
c) chordal axis



d) fan triangles



e) resulting spine



f) final triangulation

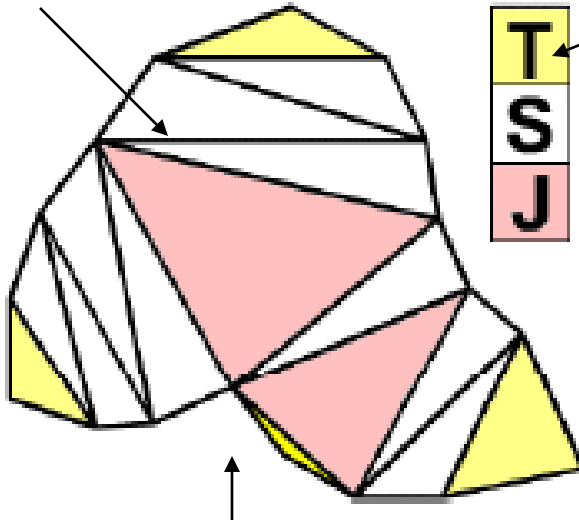


All edges length = predefined unit length

Edges = external edges (ee)

Edges $\neq ee$

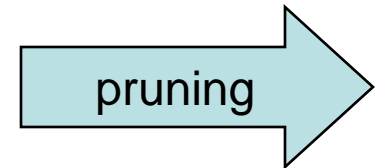
→ Internal edges (ie)



T : terminal triangle ($2ee + 1ie$)

S : sleeve triangle ($1ee + 2ie$)

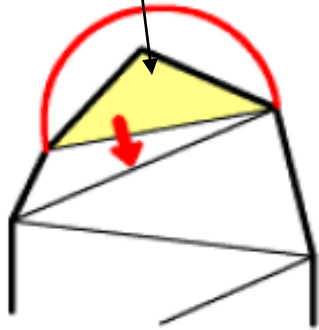
J : junction triangle ($3ie$)



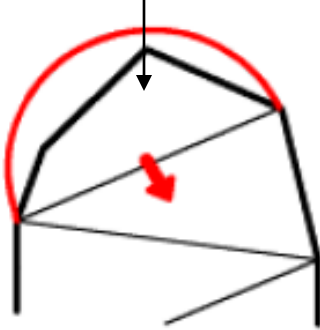
Triangulation method : constrained Delaunay triangulation (CDT)

Start from T-triangle ($2ee+1ie$)

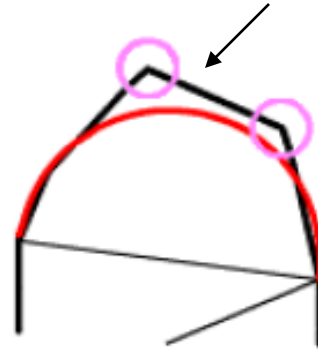
use $ie = \text{diameter}$ to draw semicircle. Connect the vertices in the external edges to the midpoint of internal edge. terminate if all T's vertices inside the semicircle. $\bar{ie} \geq \text{merge}$ terminate



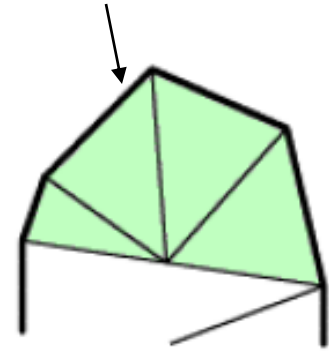
a) start from T-triangle



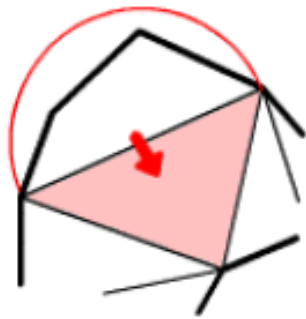
b) advance



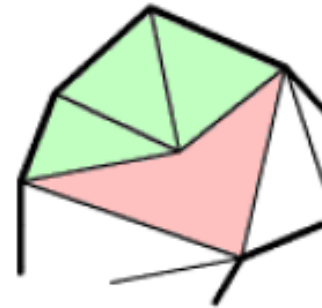
c) stop



d) fan triangles



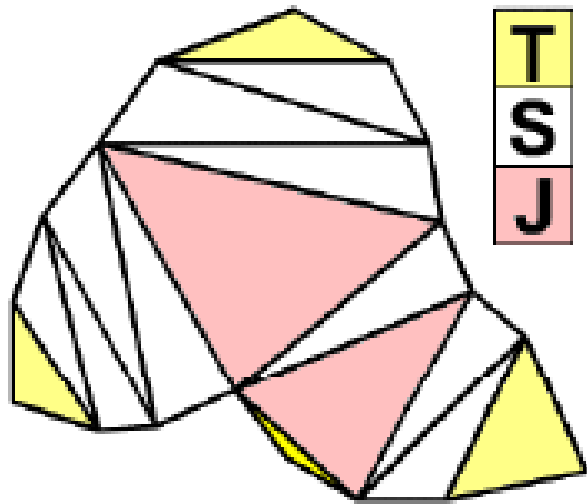
e) advance to J-triangle



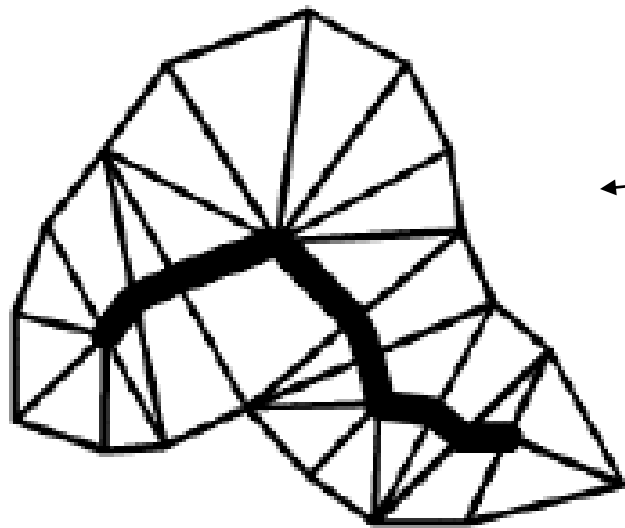
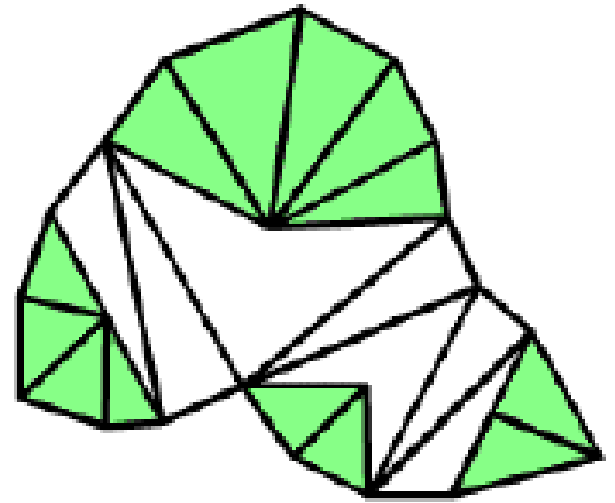
f) fan triangles at J-triangle

Merge junction triangle .

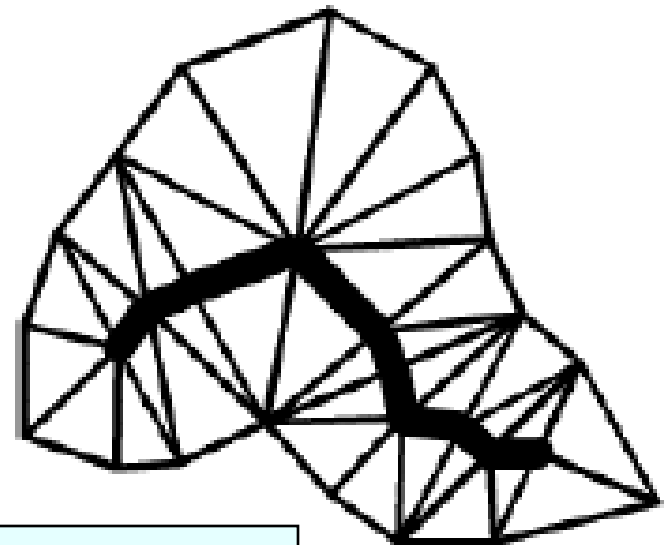
Connect the vertices in the external edges to midpoint of J-triangle



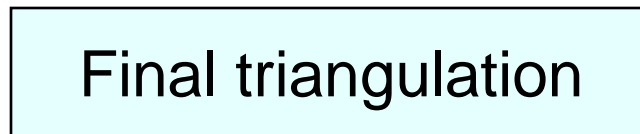
pruning



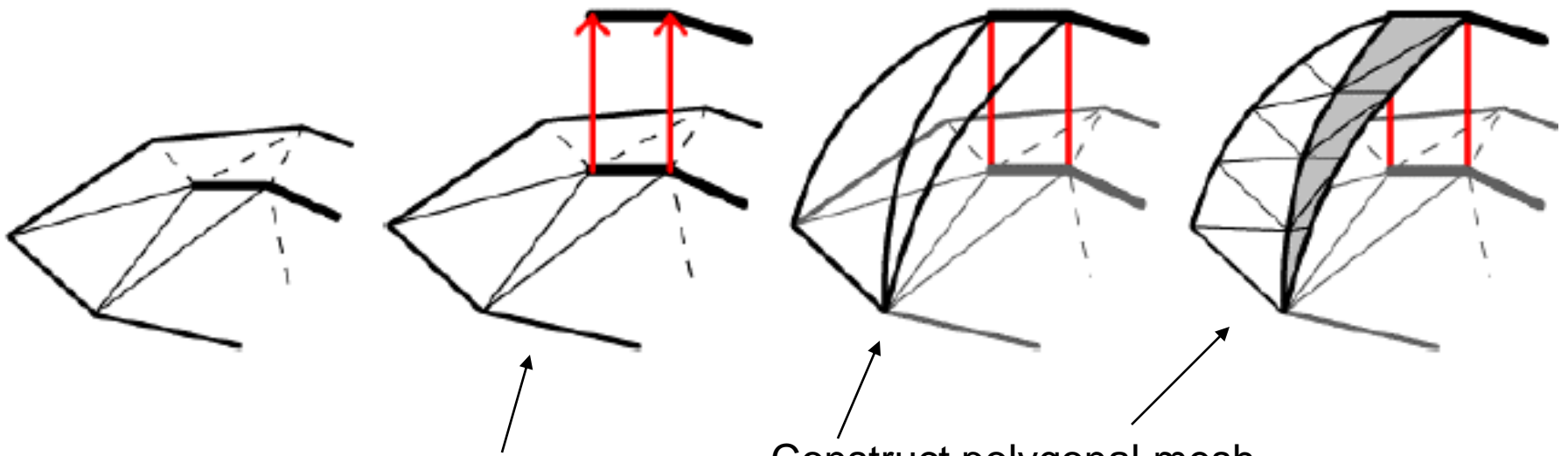
Connect the
internal
spine



Final triangulation



Elevate the vertices of spine



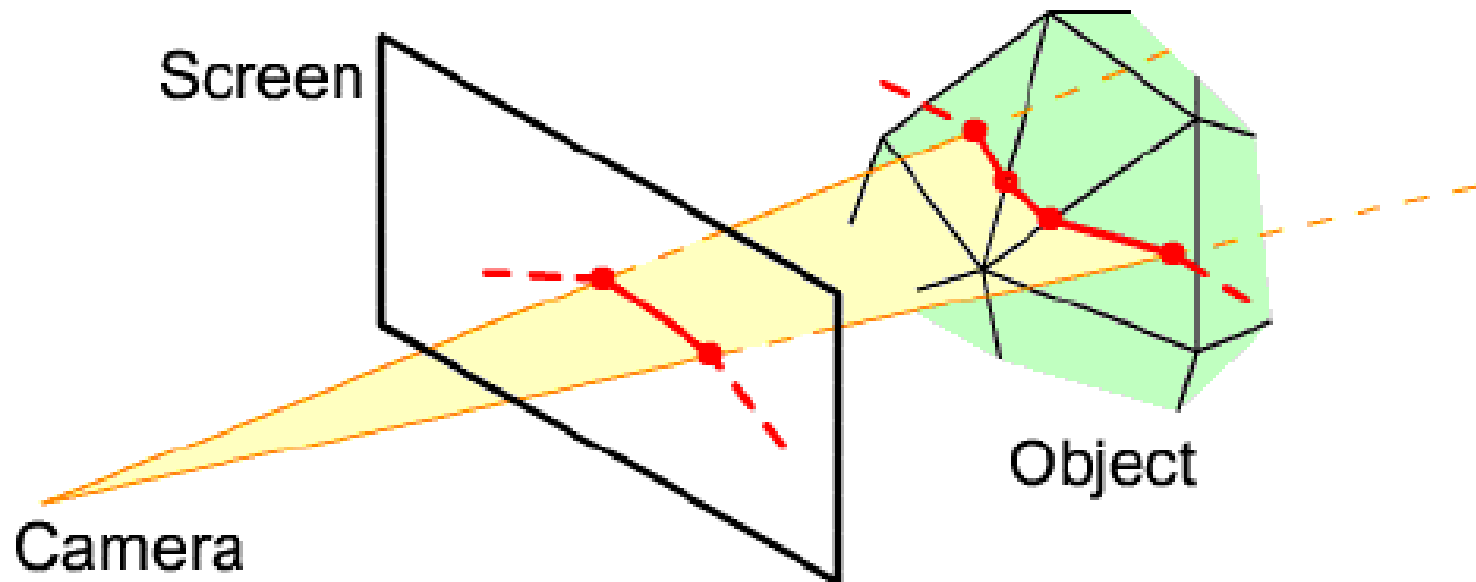
- Elevate the vertices:
1. calculate the average distance . spine vertex directly connected to the vertices of external edges \Rightarrow convert to a quarter oval
 2. elevate proportionally
- Each internal edges excluding spine edges \Rightarrow construct polygonal mesh

Construct polygonal mesh

- Copy elevated mesh to the other side
 - Make mesh closed and symmetric
- Refine mesh
 - Remove short edges
 - Remove small triangles

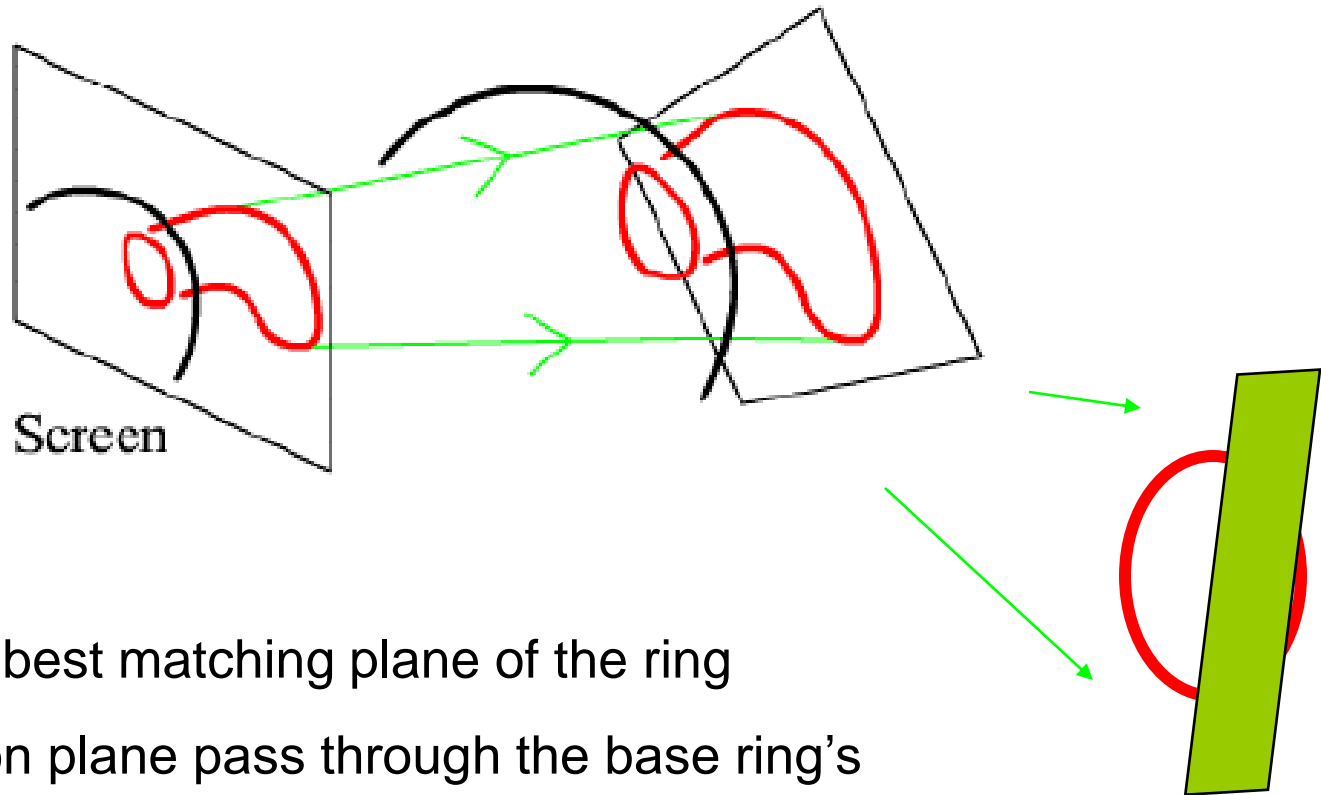
Painting on the Surface

- Find intersections between the plane and each polygon of the object
- Splices the 3D line segments together



Extrusion

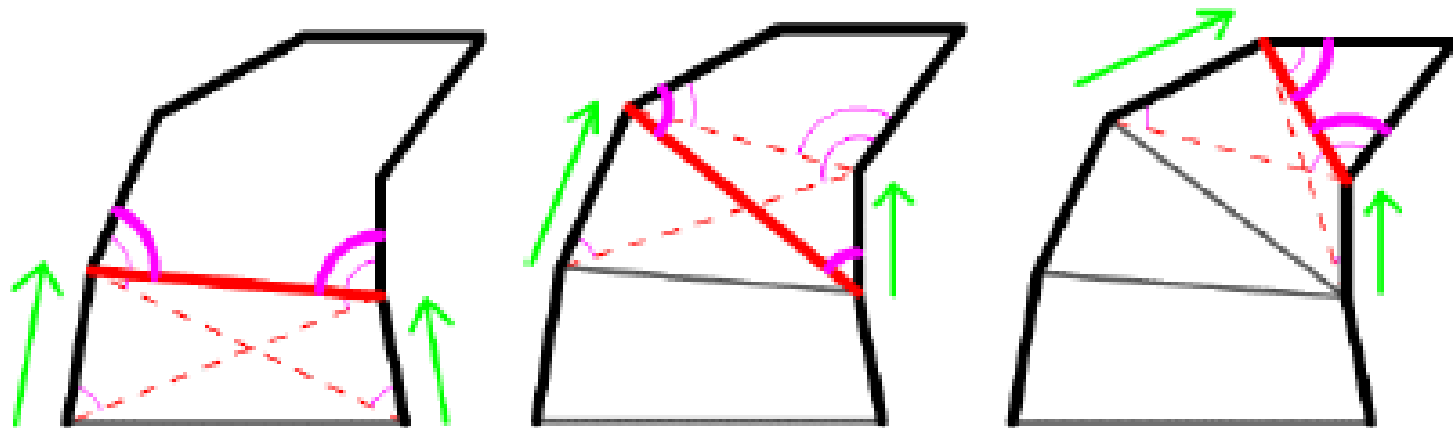
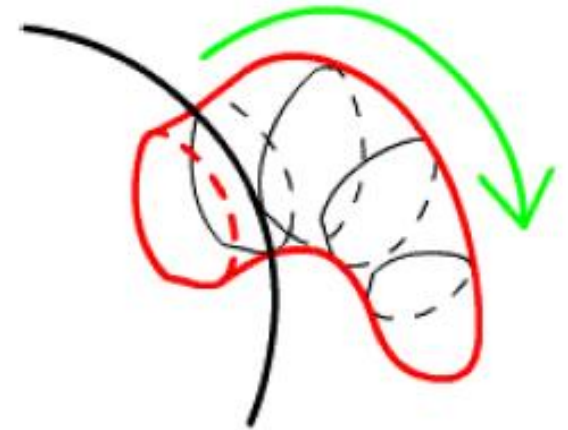
- Project and Produce 3D extruding line
- Base ring sweep along the 3D extruding line
- Construct polygonal mesh



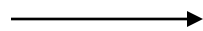
1. Find the best matching plane of the ring
2. Projection plane pass through the base ring's center of gravity and lying parallel to the normal of the base ring
3. Project the 2D extruding stroke onto the plane
4. Produce the 3D extruding stroke

Choose : advance the left pointer, the right pointer ,or both.

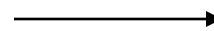
Goodness value : angle between red line and direction of strokes => closed 90 degree



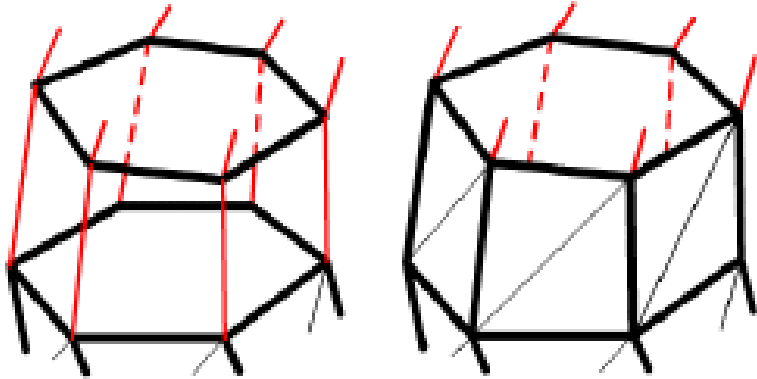
Both



Left

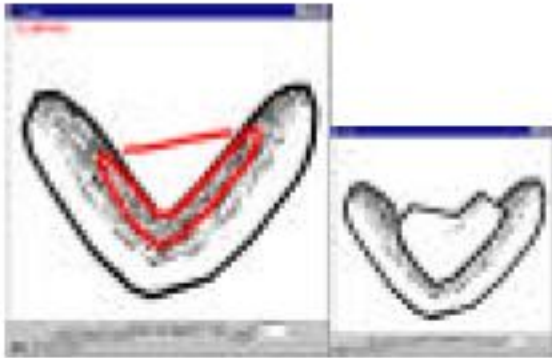


Both

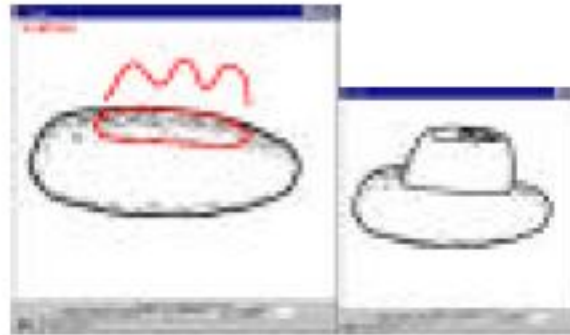


Sewing adjacent rings

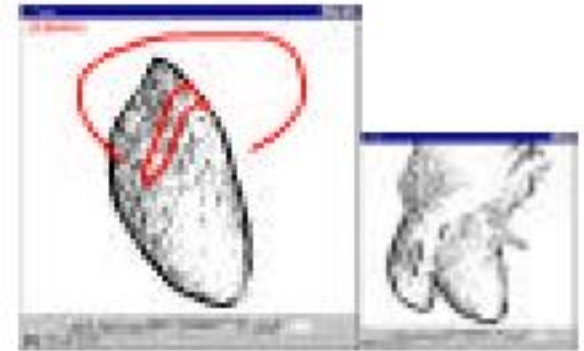
=> Done!



a) flat extrusion



b) wavy extrusion



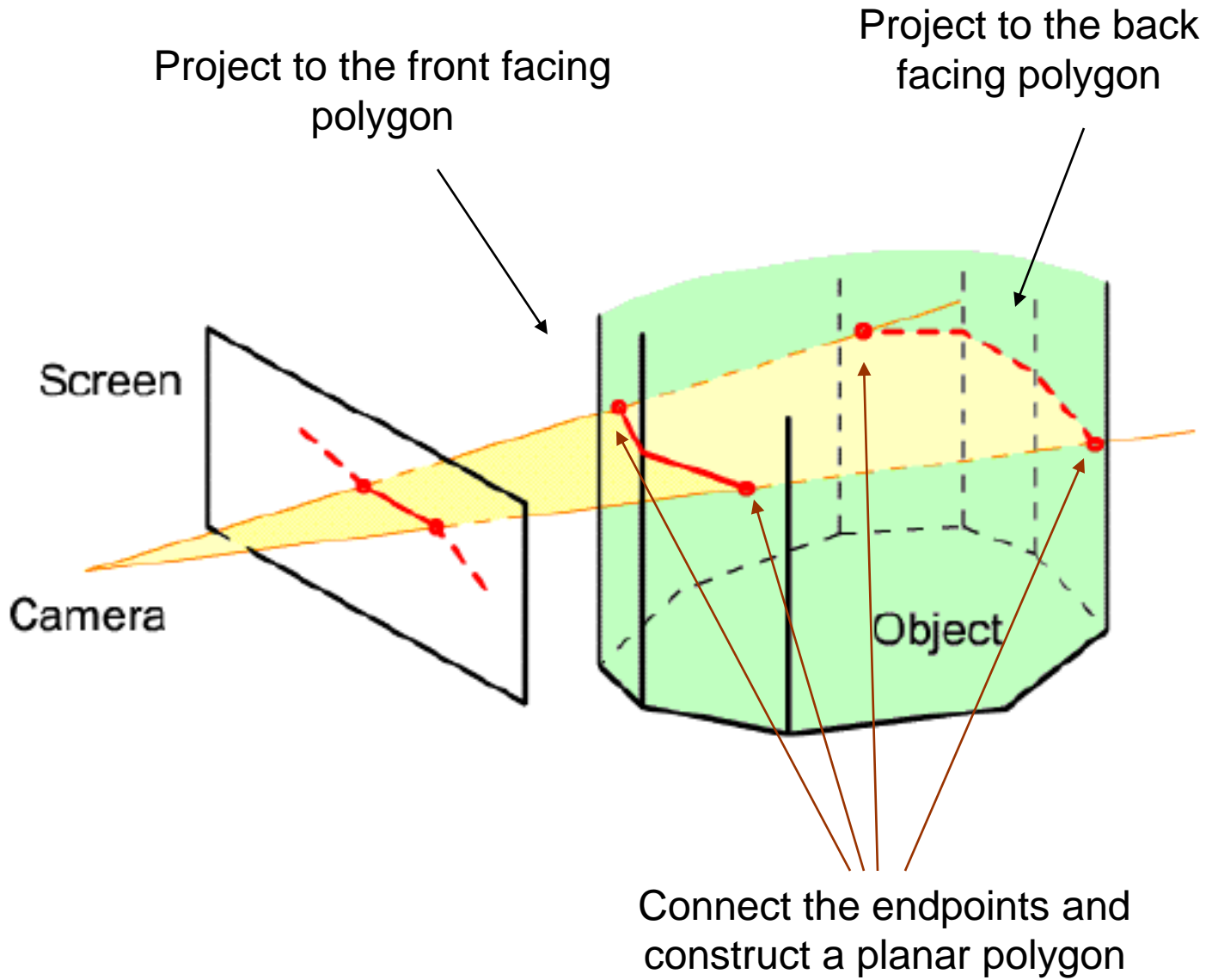
c) wrapping extrusion

Bad result caused by bad input:

unexpected extruding strokes , base surface is not sufficiently planar

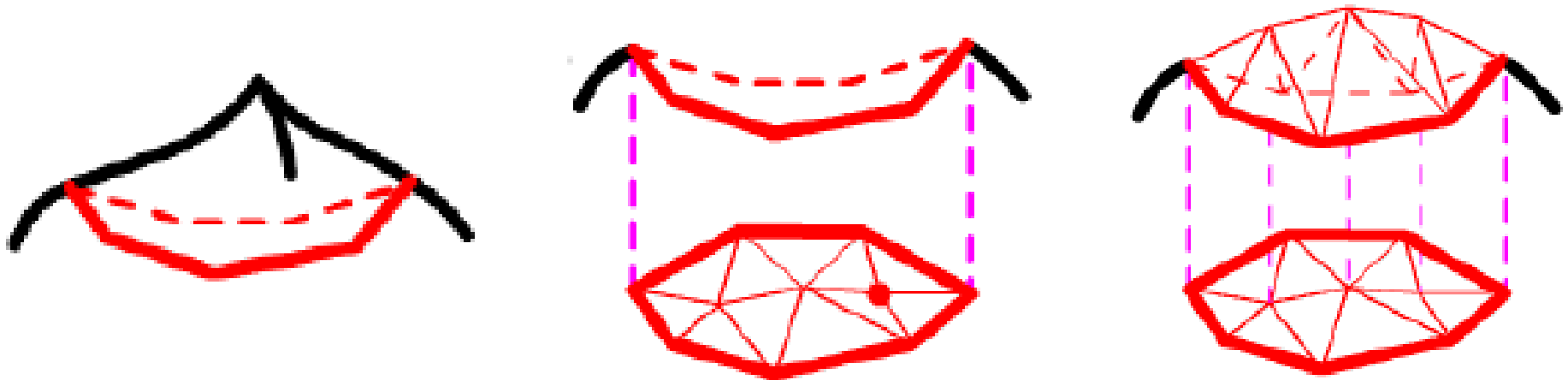
Cutting

- Based on painting algorithm
- Project onto the front and back facing polygons
- Connect endpoints to construct a planar polygon
- Cutting , remove all polygons to the left of the cutting stroke

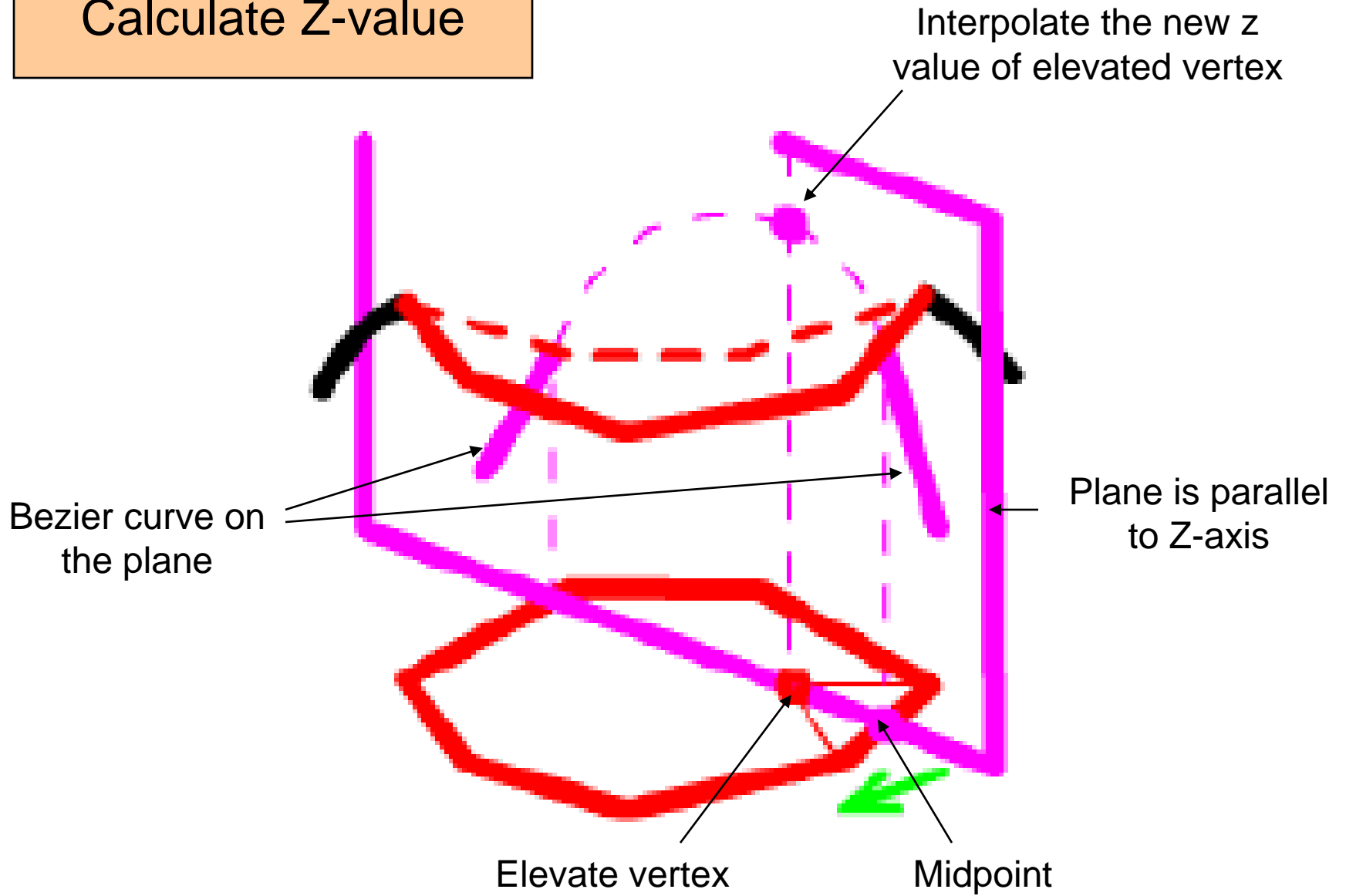


Smoothing

- Translate the object into a coordinate system , and Z-axis is parallel to the normal of the ring
- Project the ring onto XY-plane
- 2D triangulation (CDT) and refine
- Elevate each vertex



Calculate Z-value



Result

Conclusion

- Teddy is quite intuitive and encourages them to explore various 3D designs
- 5mins tutorial , 5mins practice
- Chameleon : 3D Paint for Teddy
- Commercial Products based on Teddy:



Magic sketch 2

