Balloon Fitting

Max Stegen

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Introduction

reconstruction with adapting mesh

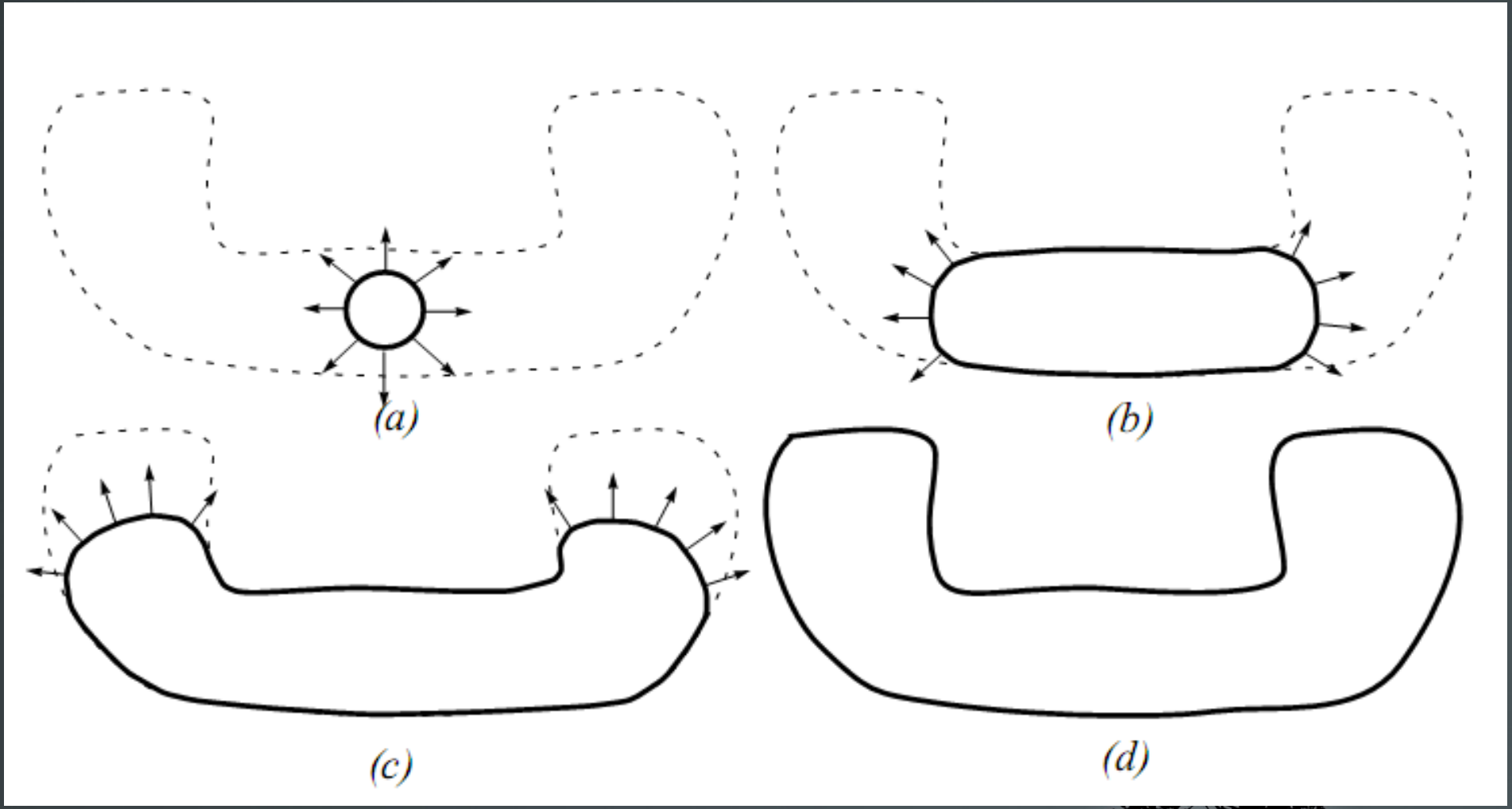
start: Icosahedron

points connected with springs

points moved with forces

move points until they reach the objects surface

Introduction - Example



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Motion Equation

$$m_i \ddot{x}_i + r_i \dot{x}_i + g_i = f_i \ , \quad i = 1...N$$

x_i : position of element i

$\dot{x}_i$: 1. derivative of x with respect to time

$\ddot{x}_i$: 2. derivative of x with respect to time

m_i : mass of element i

r_i : damping coefficient

g_i : sum of forces from neighboured elements

f_i : external force

Simplification

$m_i = 0$

$r_i = 1$

$\dot{x}_i = f_i - g_i \ , \qquad i = 1...N$

Springforce

$$s_{ij} = \frac{c_{ij} e_{ij}}{\|r_{ij}\|} r_{ij}$$

c_{ij} : stiffness of the spring

$e_{ij} = \|r_{ij}\| - l_{ij}$: deformation

$r_{ij} = x_j - x_i$

l_{ij} : natural length of the spring

$$g_i = \sum_{j=1}^{N} s_{ij}$$

Inflation Force

$$h_i = k\,\hat{n}_i$$

h_i : inflation force

k : amplitude of the force

$\hat{n}_i$: direction normal to the local model surface

$$\hat{n}_i = \frac{n_i}{\|n_i\|}\ , \qquad n_i = \sum \frac{(n_{ij} + n'_{ij})}{(\|n_{ij} + n'_{ij}\|)}$$

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Subdivision

- triangles are growing
- tension increases
  - stops the growing process
- solition: subdivide triangles
  - more triangles
  - more accurate
  - tension decreases

Subdivision (2)

just divide triangles on the front

no degenerate triangles

find triangles to subdivide

divide triangles on longest edge

divide neighboured triangles

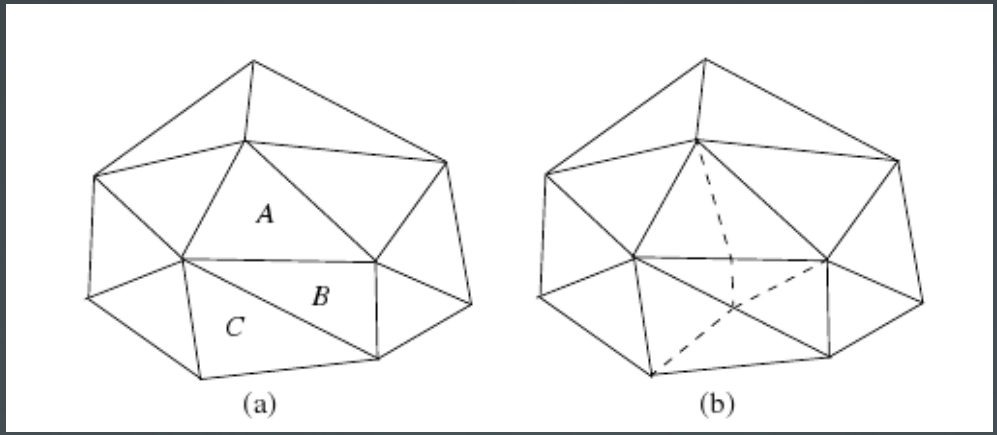
Subdivision - Algorithm

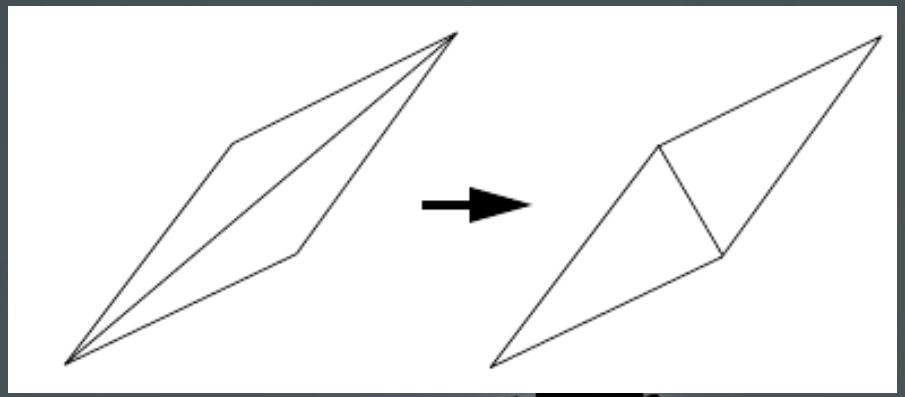
```
tf0 : set of triangles in a given front
t0 : set of triangles to subdivide

1. for each T in t0
      bisect T on the longest edge
2. find R1 (set of non-conforming Triangles from Step 1)
   k <- 1
3. for each T in Rk
      P <- non-comforming Point in T
      bisect T on the longest edge
      if P not on longest edge
         join P with longest edge
4. find Rk+1 (set of non-conforming Triangles from Step 3)
5. if Rk+1 = {0} then
      stop
   else
      k <- k + 1
      go to step 3
```

Problems

- only triangles in the front are divided
- degenerate triangles are produced





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Algorithm

chose a good point to start

place the icosahedron

put all triangles in front F0

push front F0 into queue Q

until Q is empty do following algorithm

Algorithm (2)

1. F <= top of the queue Q, pop Q
2. subdivide triangles if appropriate
3. for each vertex v_i in F
   a. compute forces g_i and $f_i = h_i$
   b. compute new location $v_i^{t+\Delta t}$
   c. w_i <- prospective cossespondence point of v_i
   d. if $\left\|v_i^{t+\Delta t} - v_i^t\right\| > \left\|w_i - v_i^t\right\|$
      $v_i^{t+\Delta t} \Leftarrow w_i$
      mark v_i as anchored
4. for each vertex v_i in F
   $v_i^t \Leftarrow v_i^{t+\Delta t}$
5. discard anchored triangles from F
6. if F = {0}
   go to 1
7. recompute conntected triangle regions in F and push them into Q
   go to 1

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Holes & Noise

holes: no correspondence point for whole front

- set inflation force = 0 (k = 0)
- front reaches equilibrium state
- interpolation over the hole

noise: errors in the object

- often dealt with by line-surface intersection algorithm
- good possibilities to filter things out

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Conclusion

object reconstructed by inflating balloon model

growing simulated by physical forces

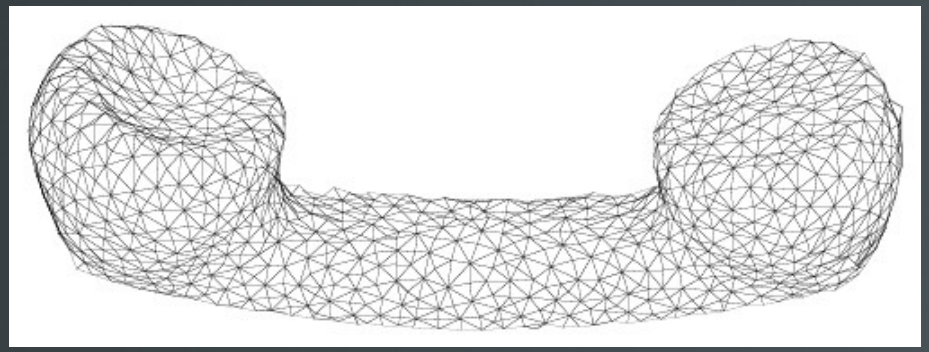
triangles subdivided to keep mesh growing

good handling of holes and noise

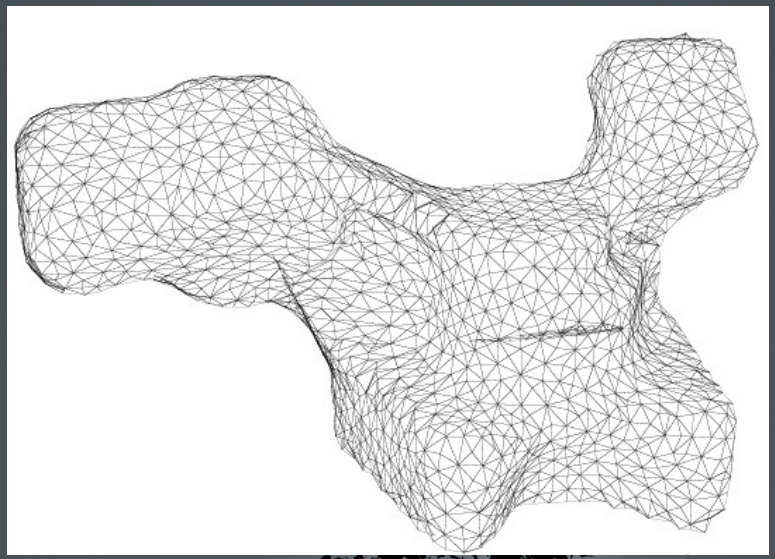
Test Results

Sun Sparc-10, Lucid Common Lisp v. 4.0

1694 vertices
3384 triangles
16m, 17s



2850 vertices
5696 triangles
32m, 26s



Reference

Yang Chen, Gerard Medioni : *2 Description of Complex Objects from Multiple Range Images Using an Inflating Balloon Model*