

# Animation & Simulation

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# Special Models for Animation

- Covered
  - Interpolation schemes
  - Motion control
  - Kinematics
  - Physically-based animation
  - Fluid dynamics
  - ...
- Bits here and there, useful but fragmented knowledge
  - Implicit surfaces
  - Plants

# Special Models for Animation

- Implicit Surfaces
  - $f(P) = 0$ 
    - To test if a point  $x$  is on the surface,  $f(x) = 0$  yes, otherwise no
    - $f(x, y) = x - y$
  - Why? Given we have explicit and parametric surfaces
    - Good for representing a compounding surface generated by primitive functions
    - Usually very smooth and organic-looking
    - Easily change topologies in animation

# Special Models for Animation

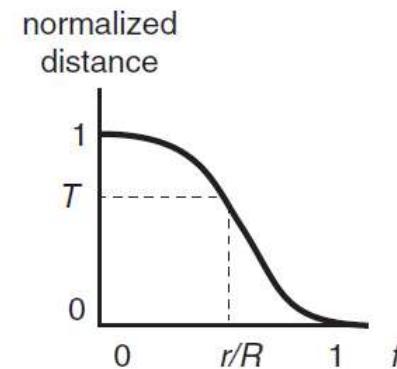
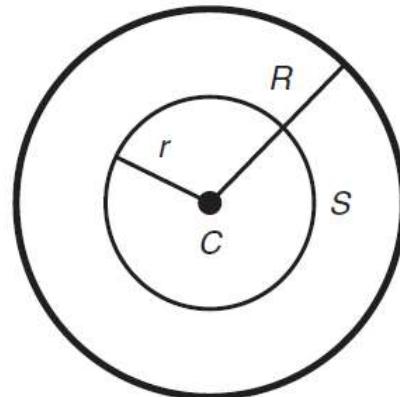
- Implicit Surfaces

- $f(P) = 0$ , basic formulation
- How to construct a polygonal surface out of  $f$ ?
  - Ray-trace, sample points where  $f(P) = 0$
  - Then construct edges, e.g. via triangulations
- Example
  - A centre point  $c$  and a distance  $r$ :  $f(x) = ||x - c|| - r$
  - Two centre point  $c_1$  and  $c_2$  and a distance  $r$ :  $f(x) = ||x - c_1|| + ||x - c_2|| - r$
  - What about three centres? Try

# Special Models for Animation

- Implicit Surfaces

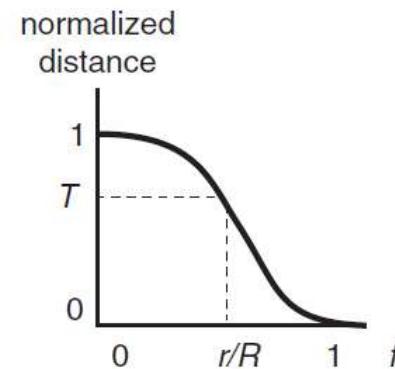
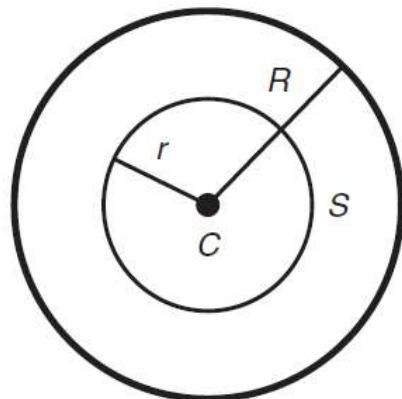
- Metaball, the best known primitive
  - A centre ( $C$ ), influence radius ( $R$ ), density function ( $f$ ) and the threshold ( $T$ )
  - $f(||P-C|| / R)$ , a function of normalised distance.
  - $f(||P-C|| / R) - T = 0$  defines a surface



# Special Models for Animation

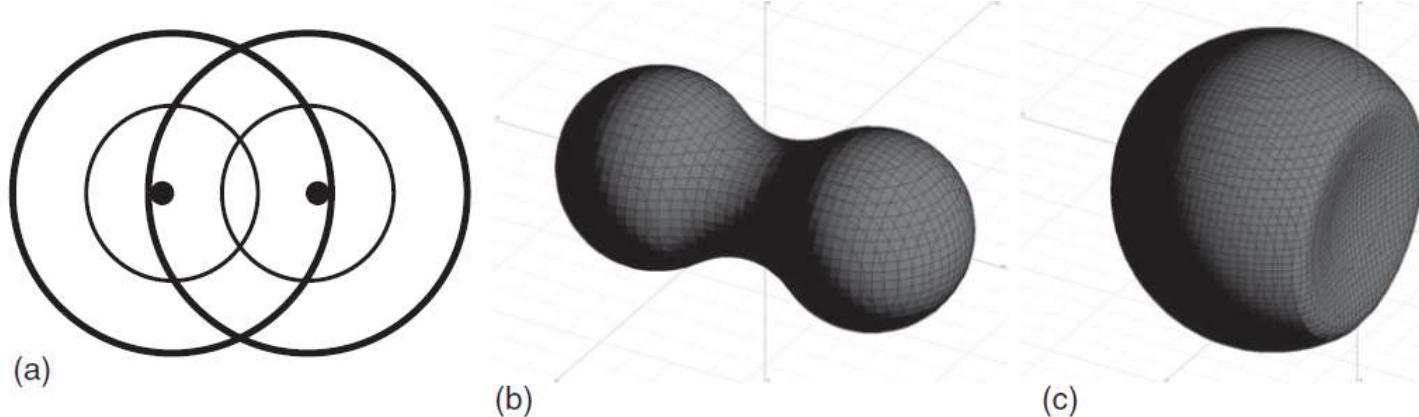
- Implicit Surfaces
  - Metaball, the best known primitive
    - Desirable properties of  $f$ :  $f(0.0) = 1$ ,  $f(0.5) = 0.5$ ,  $f(1.0) = 0$ ,  $f'(0.0) = f'(1.0) = 0$

$$f(s) = 1 - \left(\frac{4}{9}\right)s^6 - \frac{17}{9}s^4 - \frac{22}{9}s^2 \quad \text{Wyvill B, et al. 1986}$$



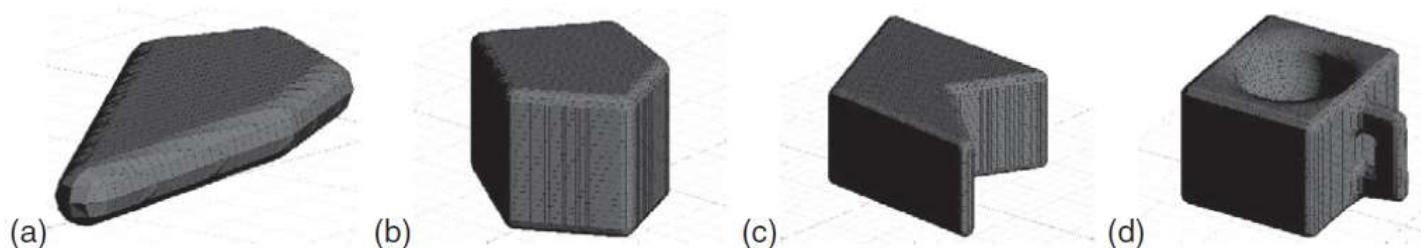
# Special Models for Animation

- Implicit Surfaces
  - Metaball, the best known primitive
    - Generalisation 1:



# Special Models for Animation

- Implicit Surfaces
  - Metaball, the best known primitive
    - Generalisation 2: centres as geometric primitives



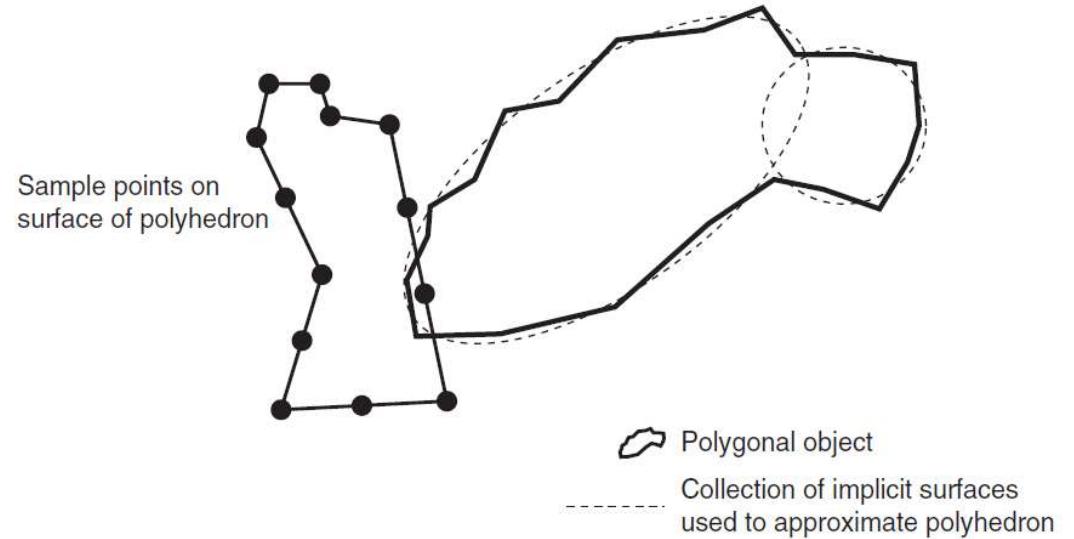
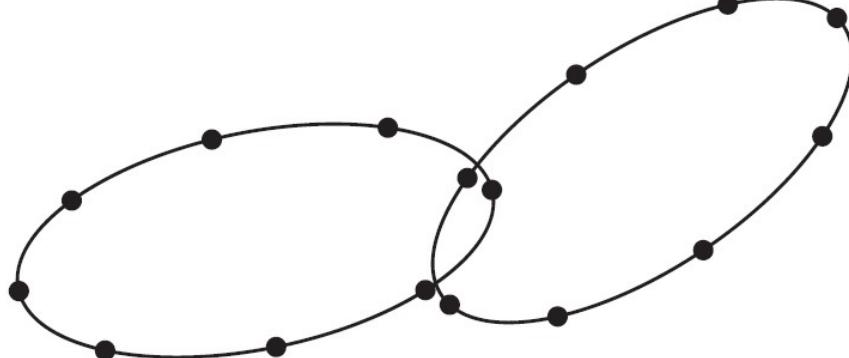
Various surfaces extracted from implicit distance-based functions. (a) Distance-based implicit primitive based on a single polygon. (b) Distance-based implicit primitive based on a single convex polyhedron. (c) Distance-based implicit primitive based on a single concave polyhedron. (d) Compound implicitly defined object.

# Special Models for Animation

- Implicit Surfaces
  - Animation using implicitly defined objects
    - Control the underlying central elements
    - Or more advanced e.g. changing between different isosurfaces

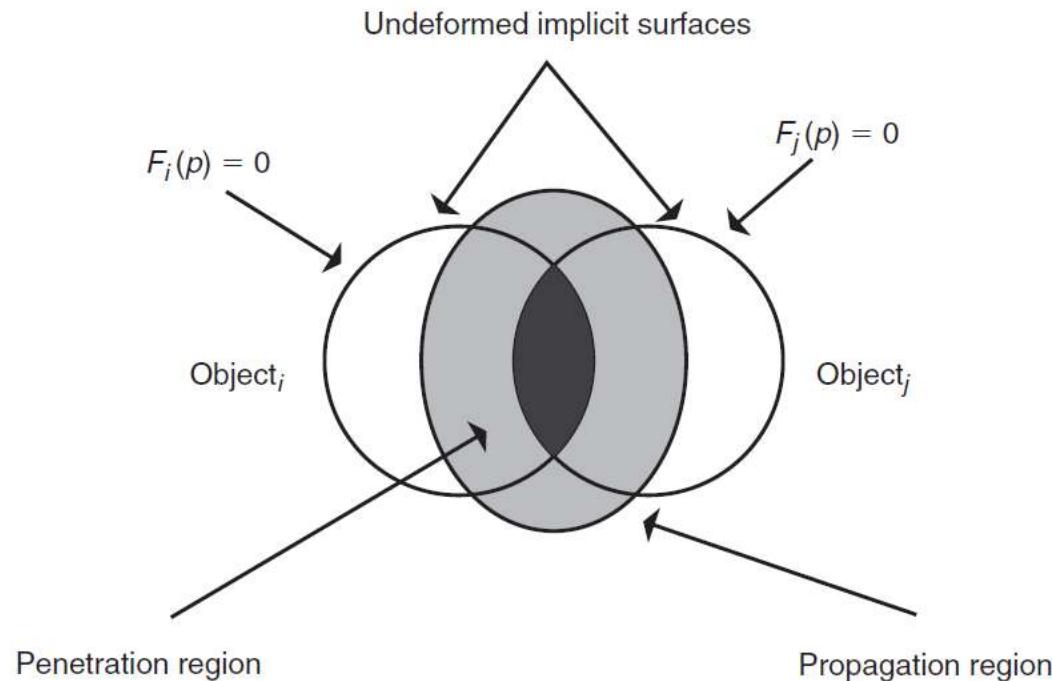
# Special Models for Animation

- Implicit Surfaces
  - Collision Detection



# Special Models for Animation

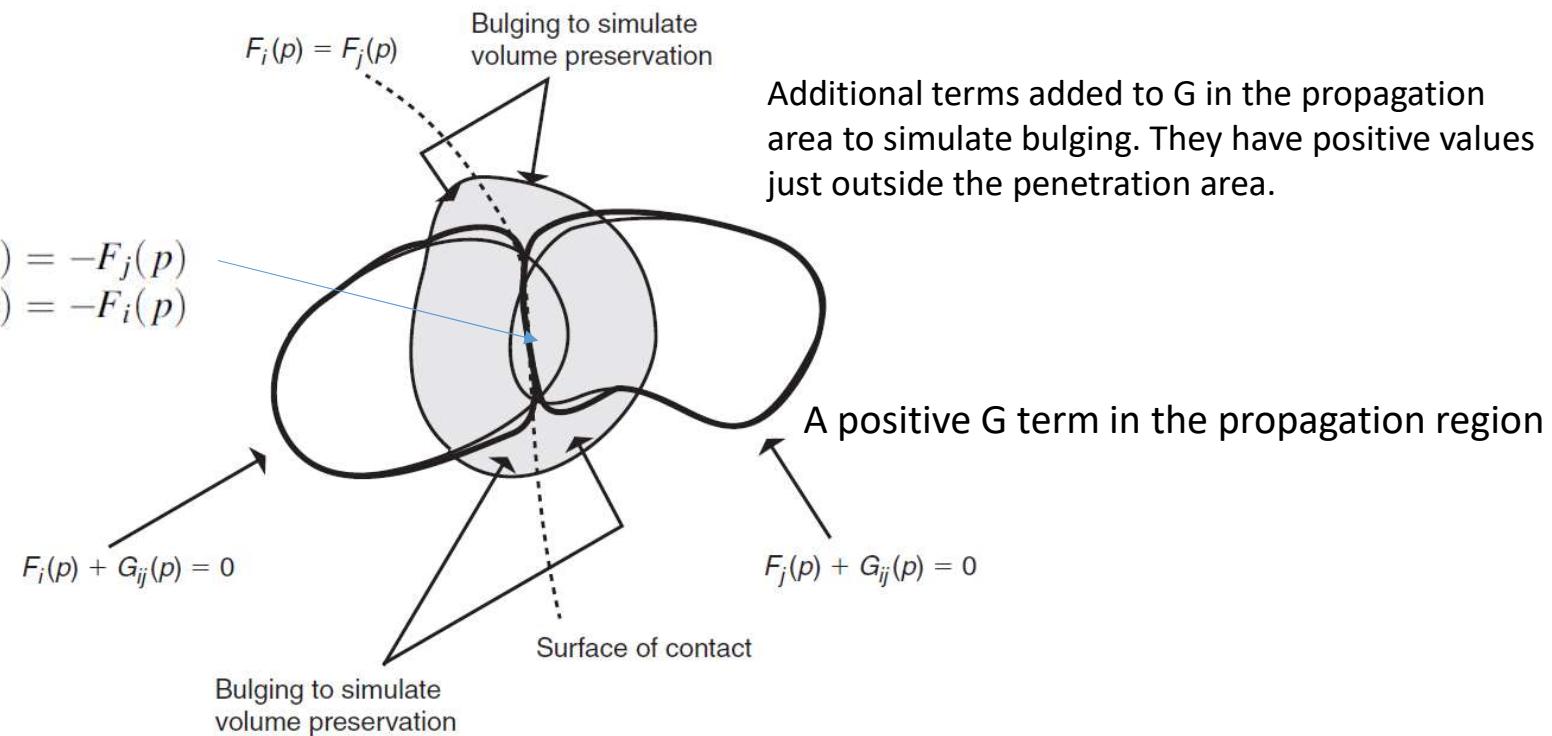
- Implicit Surfaces
  - Deforming the implicit surface as a result of collision



# Special Models for Animation

- Implicit Surfaces
  - Deforming the implicit surface as a result of collision

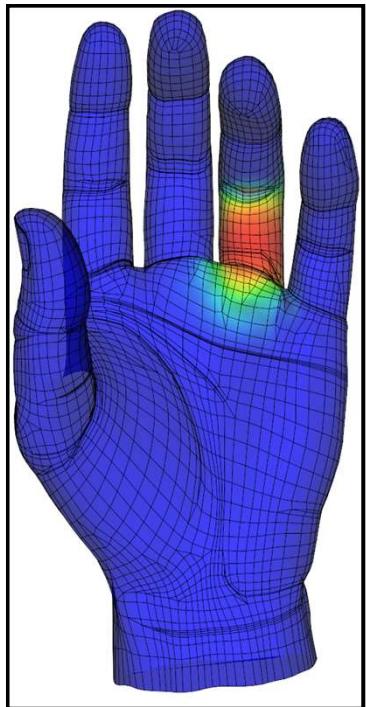
In the penetration region,  $G_{ij}(p) = -F_j(p)$   
G is negative to cancel F     $G_{ji}(p) = -F_i(p)$



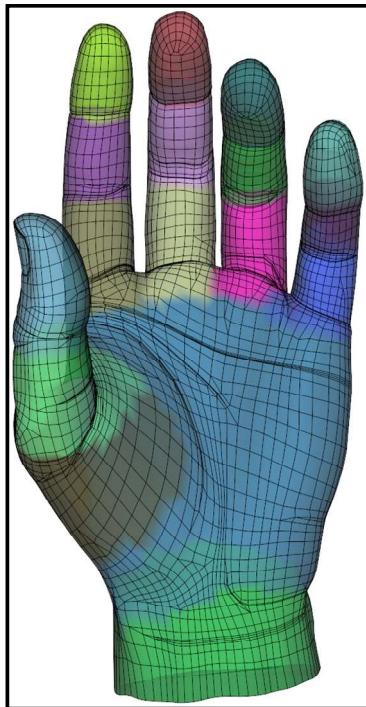
# Special Models for Animation

- Implicit Surfaces
  - Animation using implicitly defined objects
    - Elastic Implicit Skinning [Vaillant et al. SIGGRAPH 2014]

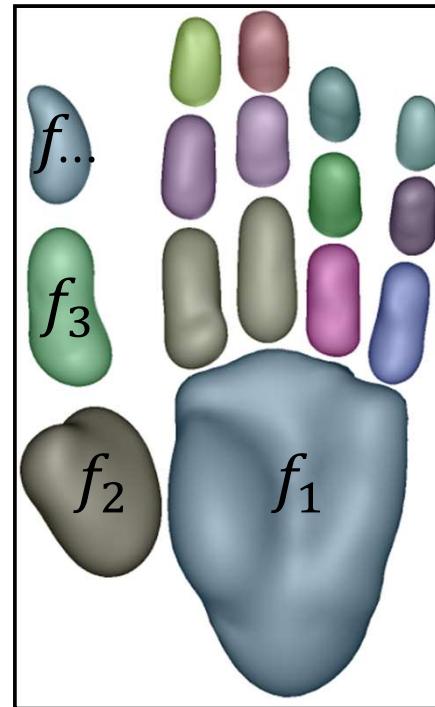
# Implicit skinning: overview



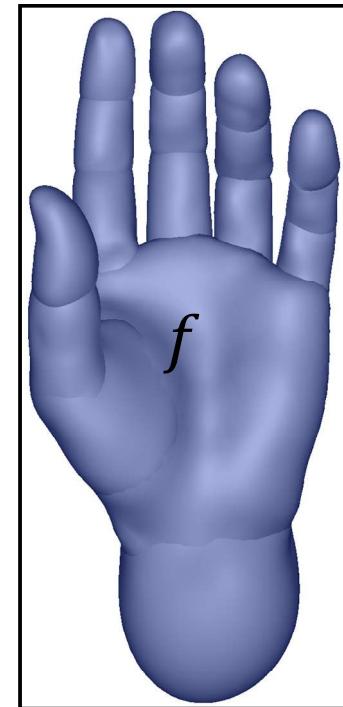
Skinning weights



partitioning

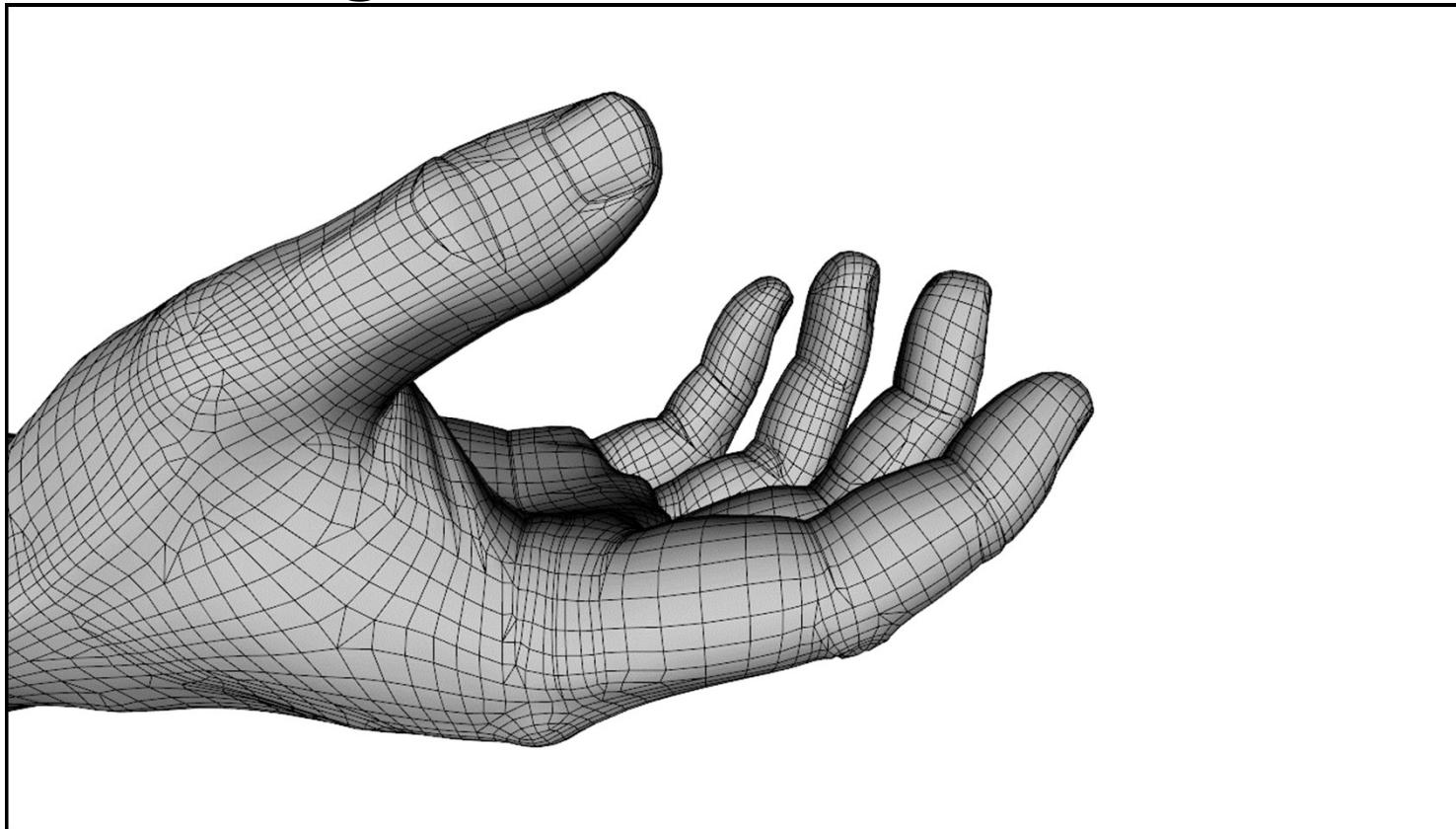


1 partition  
=  
1 distance field  $f_n$

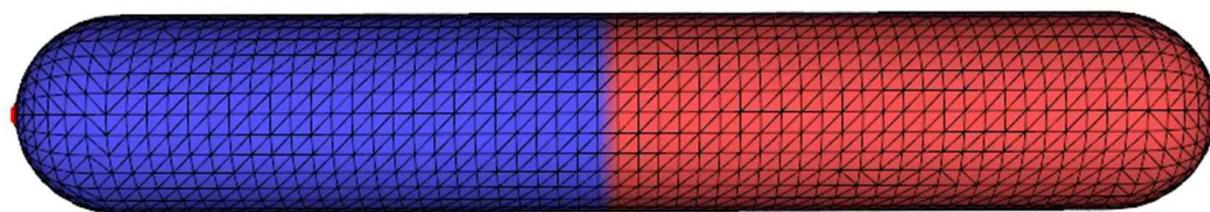


Global distance field  
 $f: \mathbb{R}^3 \rightarrow \mathbb{R}$

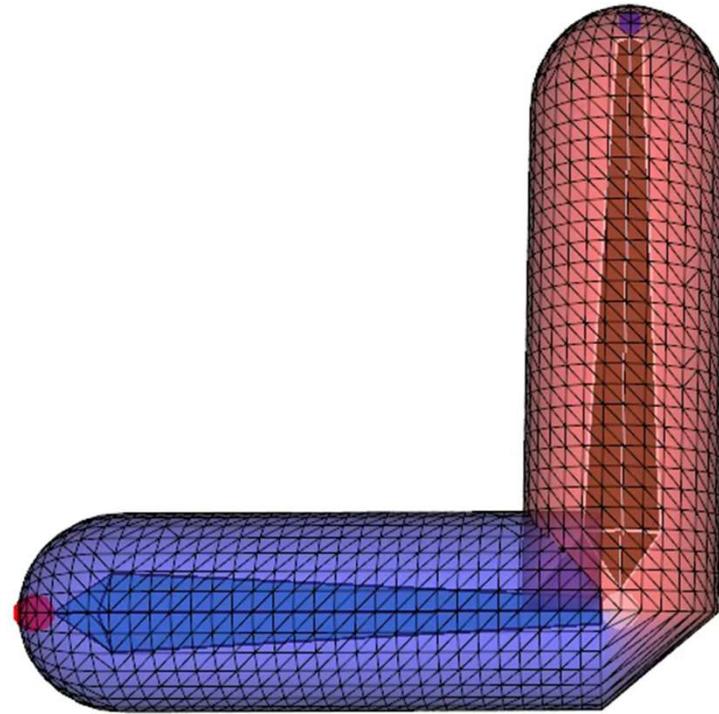
# Implicit skinning: overview



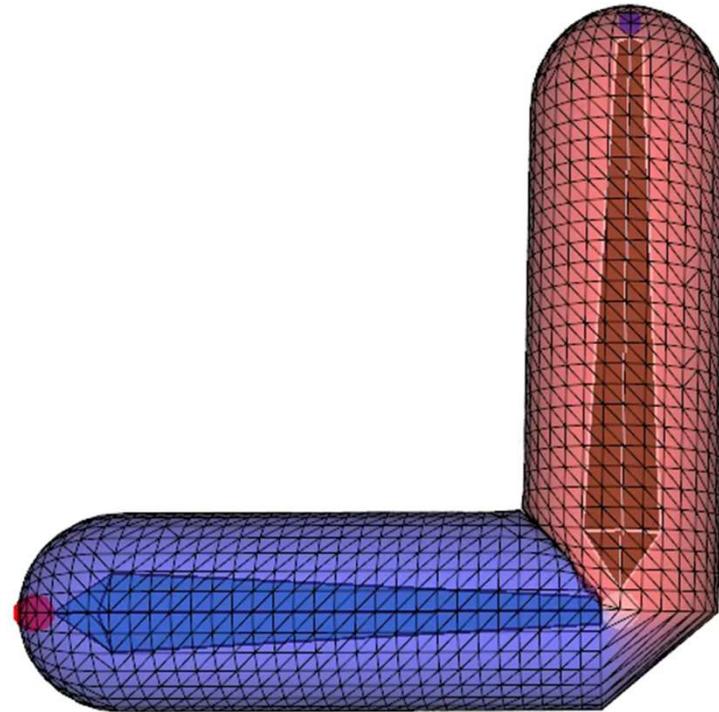
# Our approach step by step



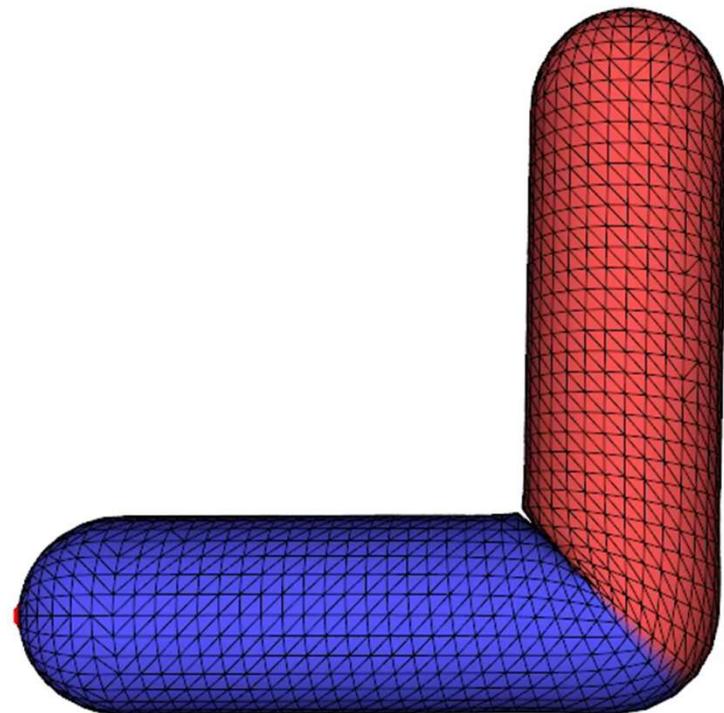
# Our approach step by step



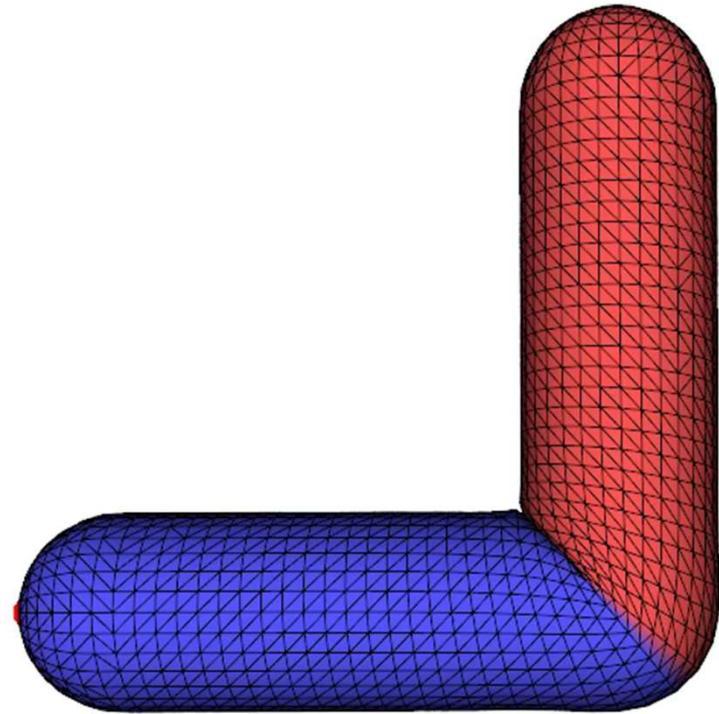
# Our approach step by step



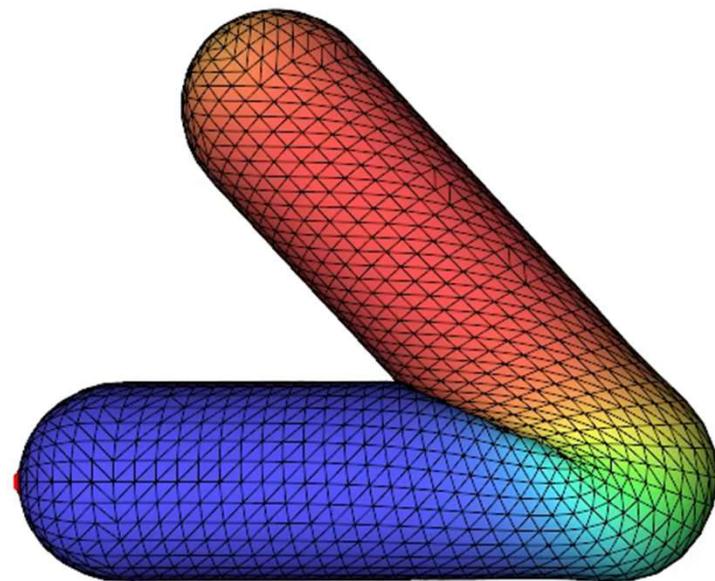
# Our approach step by step



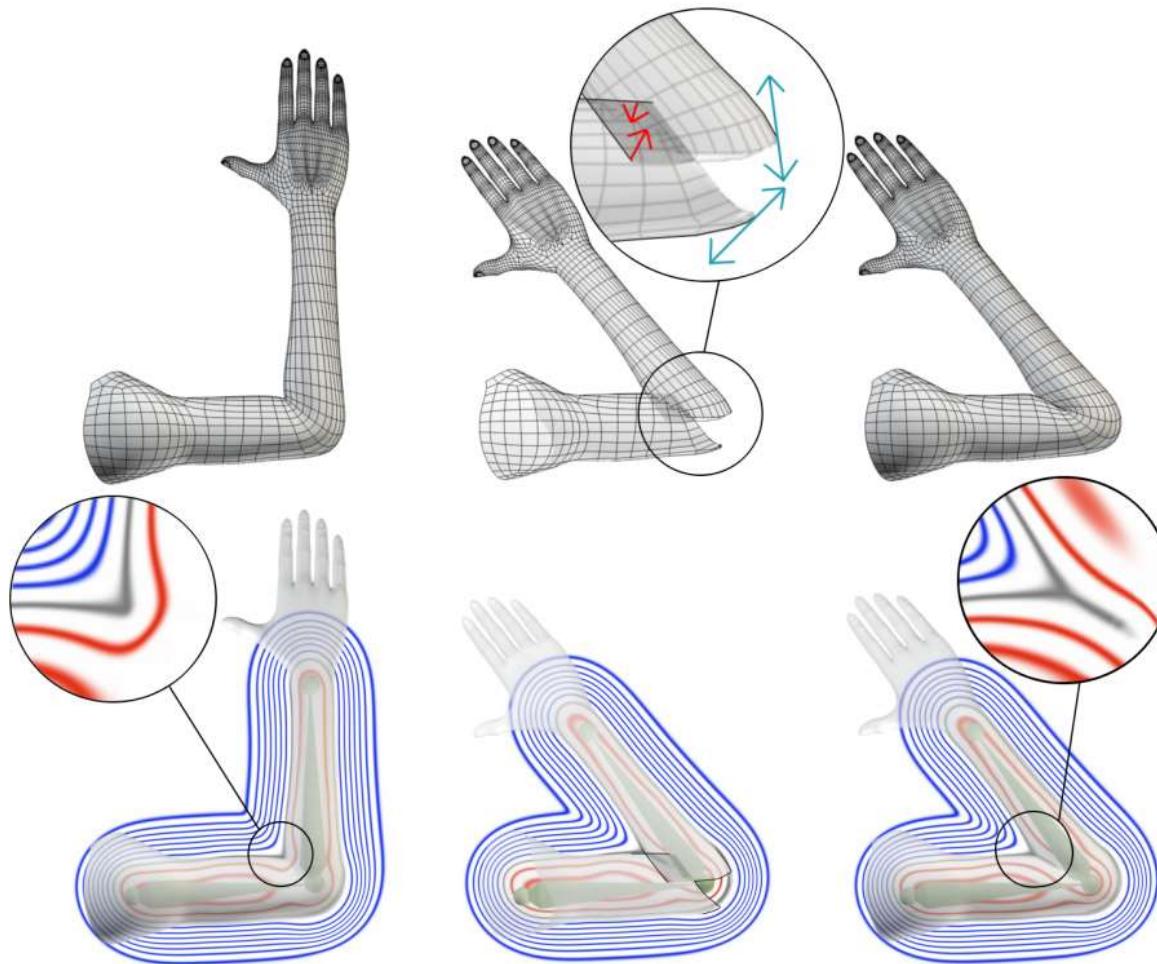
# Our approach step by step



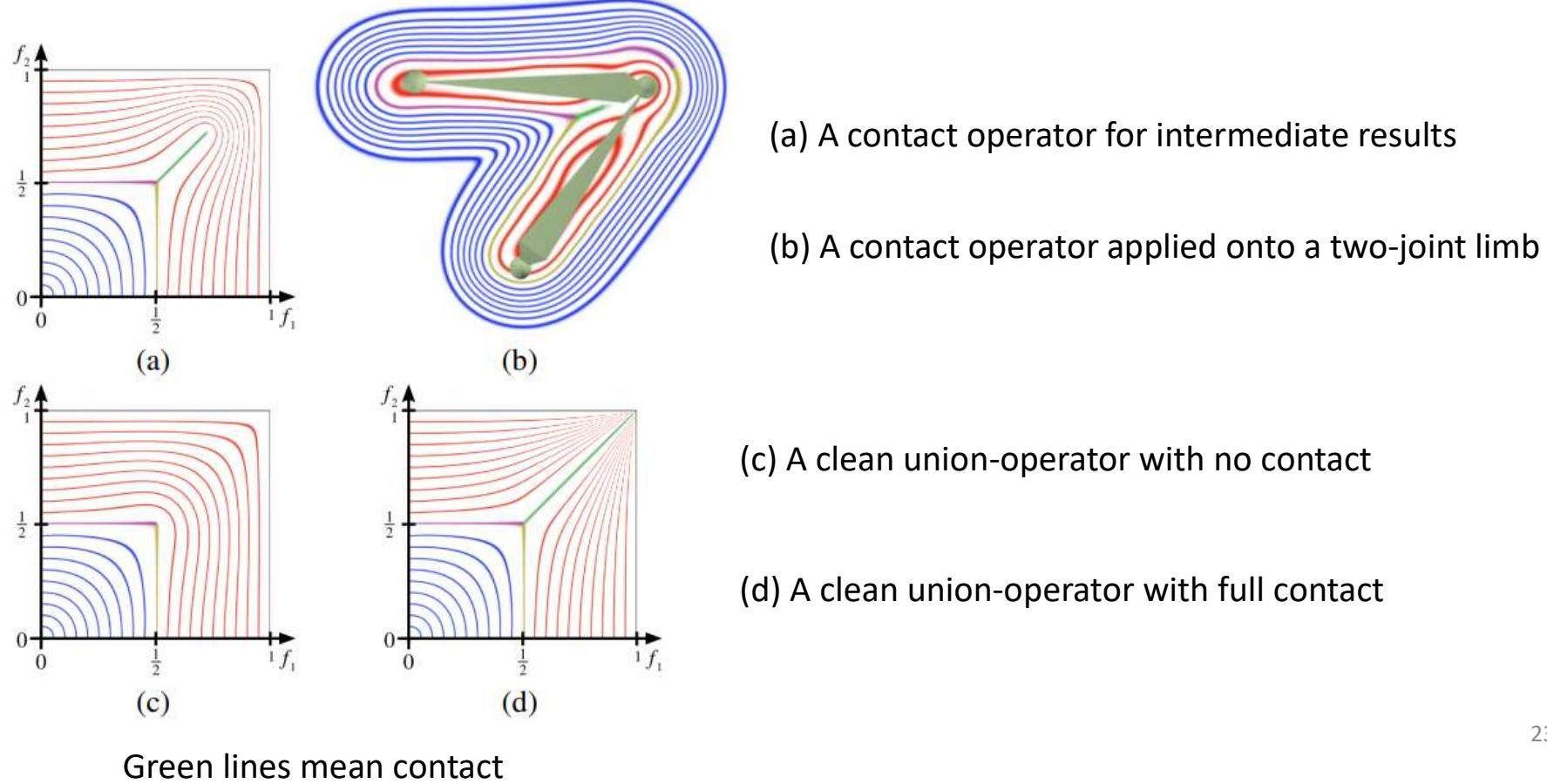
# Our approach step by step



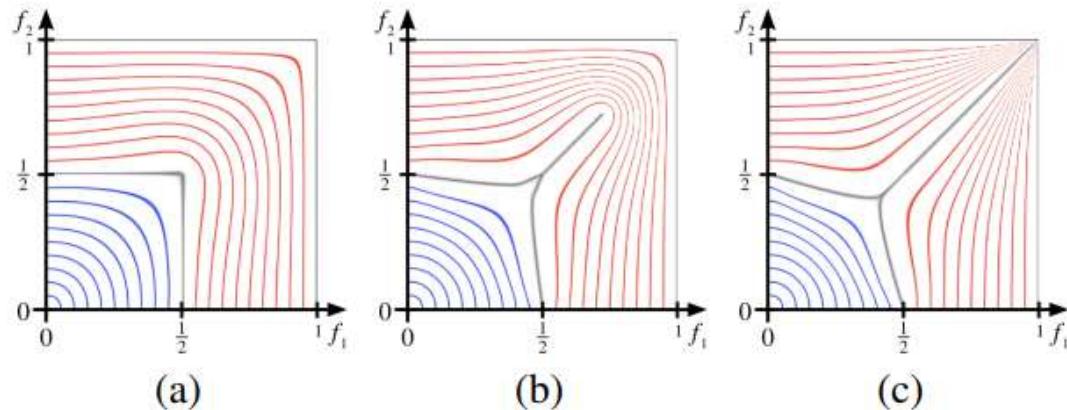
# Our approach step by step



# Our approach step by step



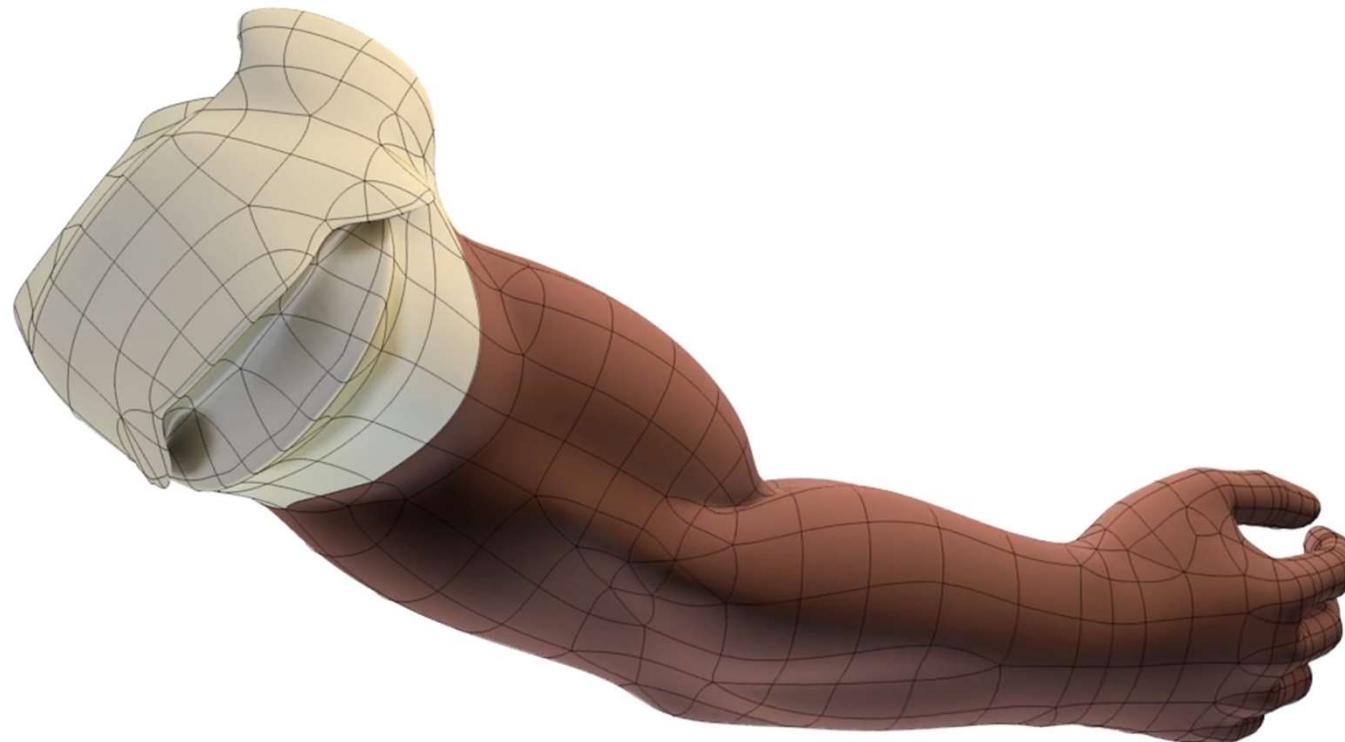
# Our approach step by step



- (a) A clean union-operator with no contact
- (b) An interpolation between full-contact and no-contact
- (c) A clean union-operator with full contact

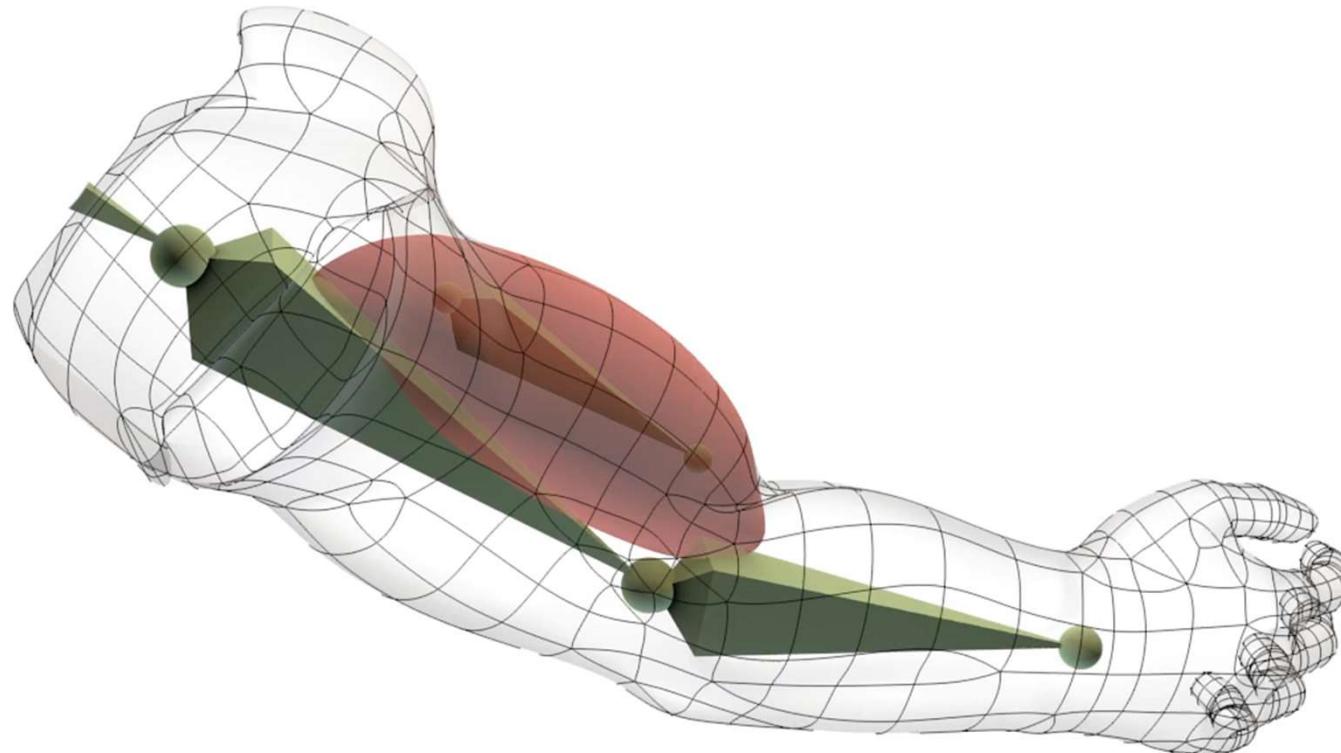
# Results: muscle bulge

Implicit Skinning

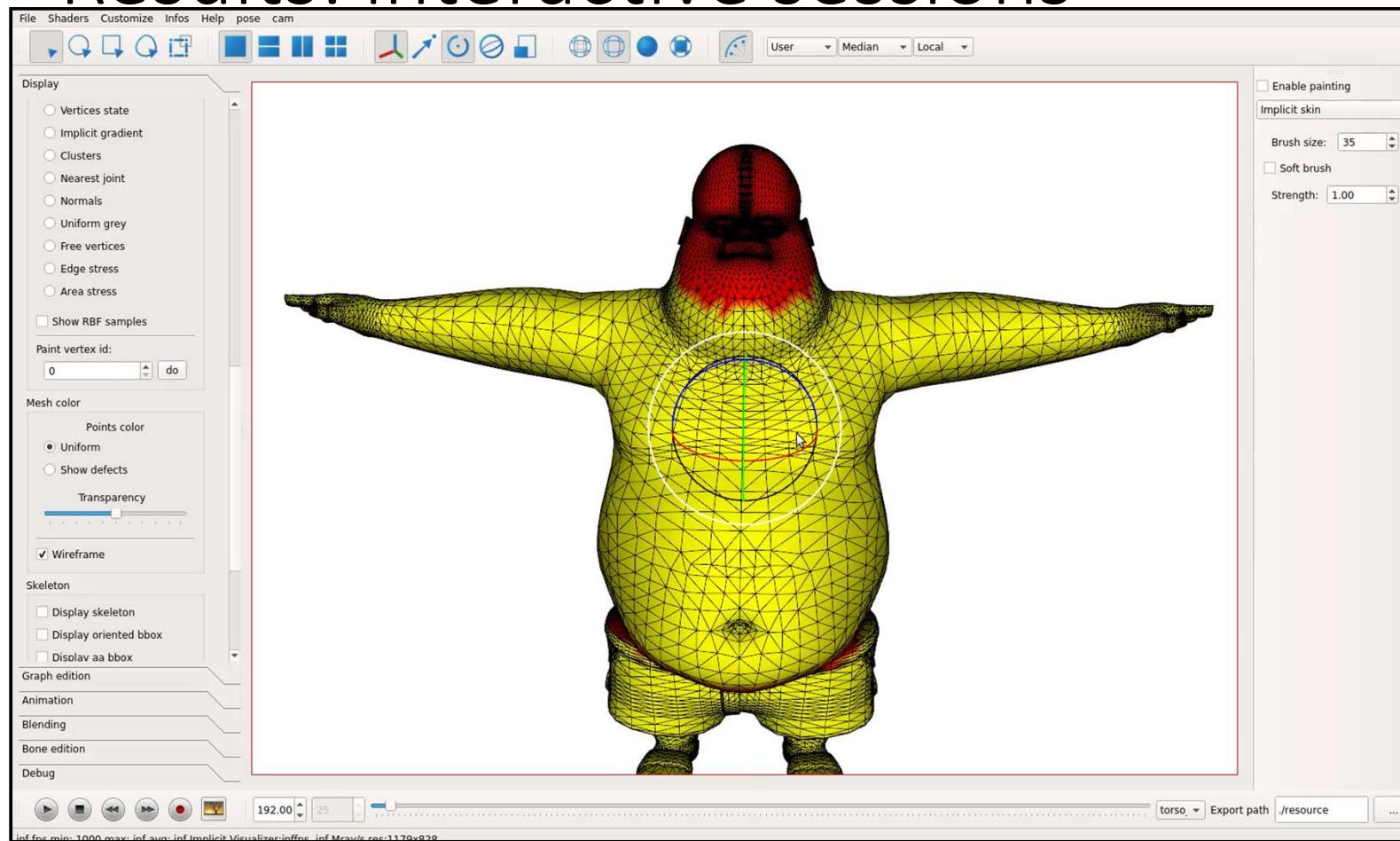


# Results: muscle bulge

Ours



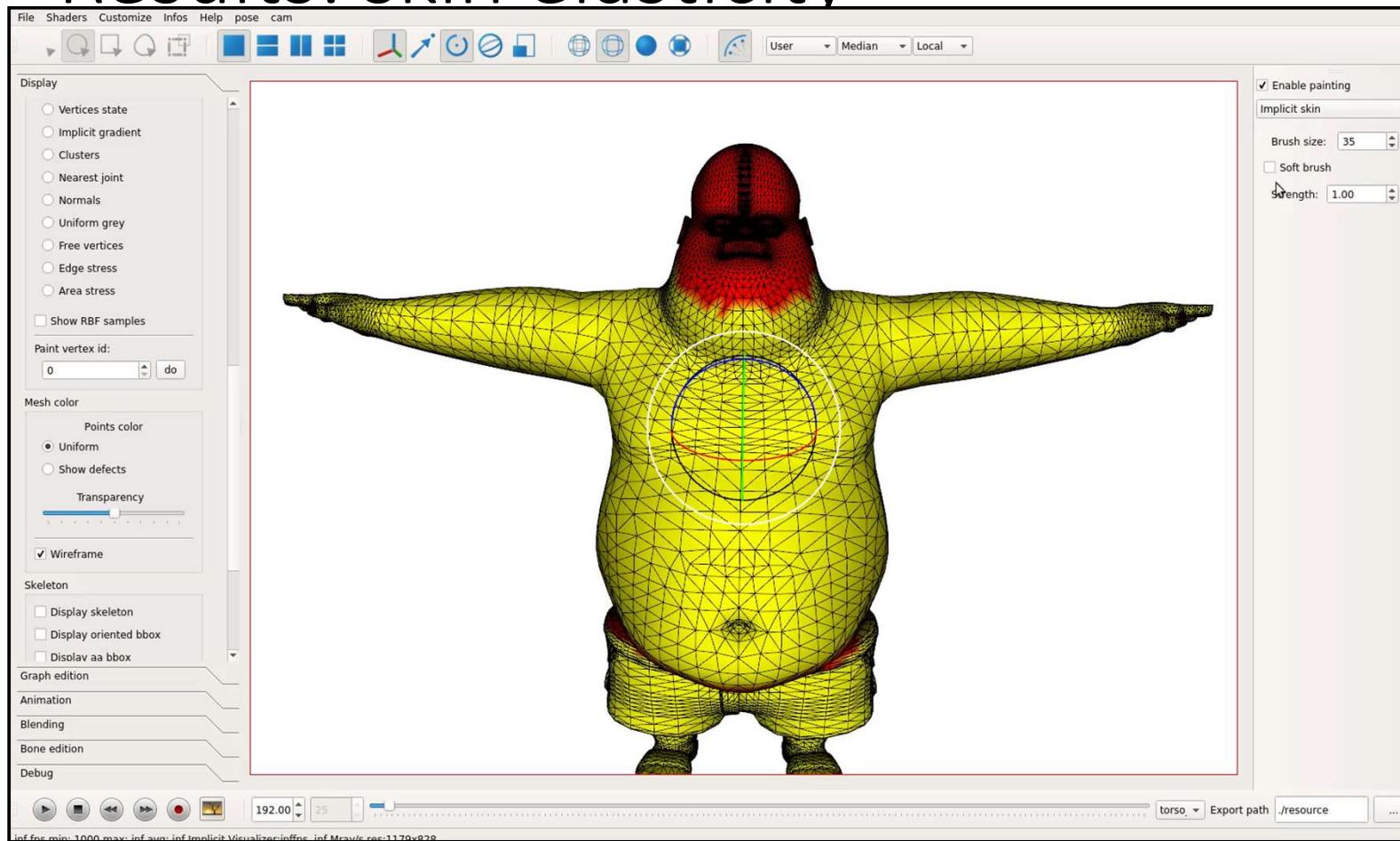
# Results: interactive sessions



Hardware:  
Geforce 680 GTX and  
Intel Core i7

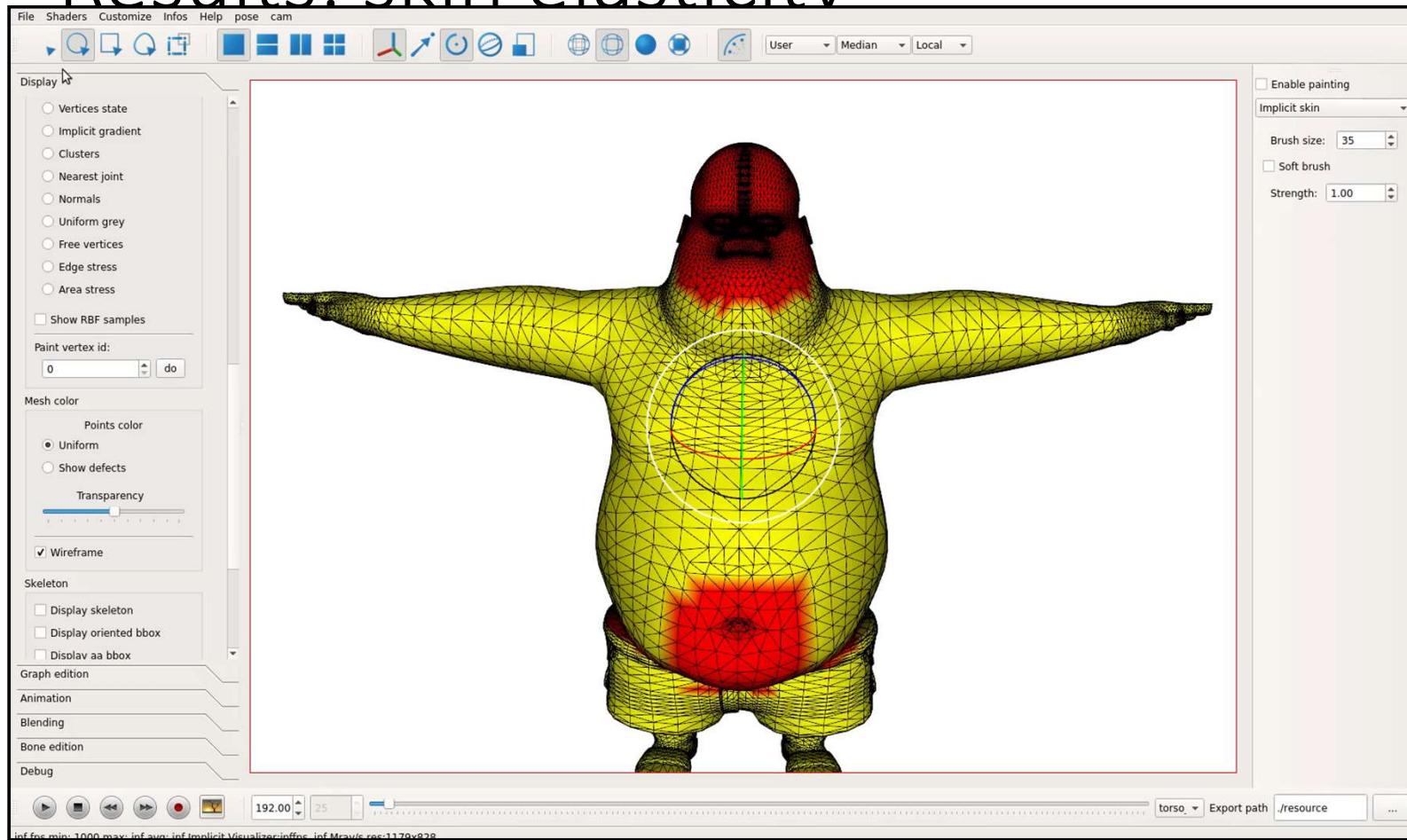
13K vertices  $\approx$  20fps

# Results: skin elasticity



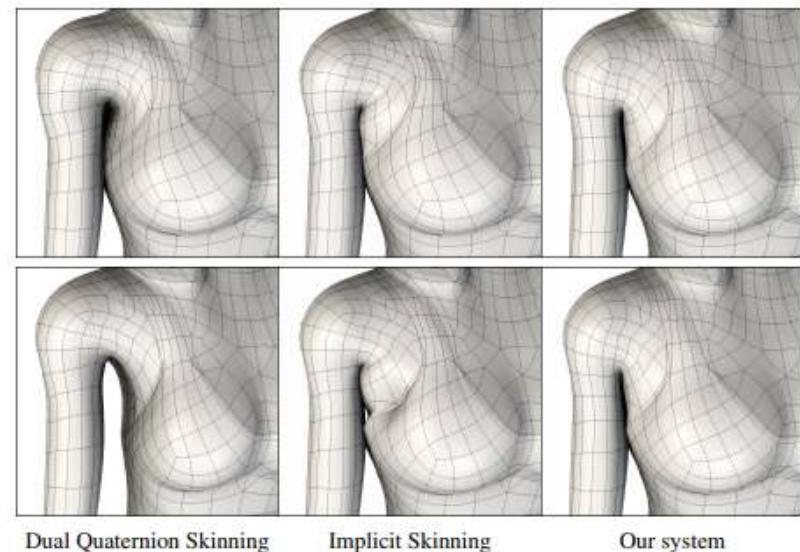
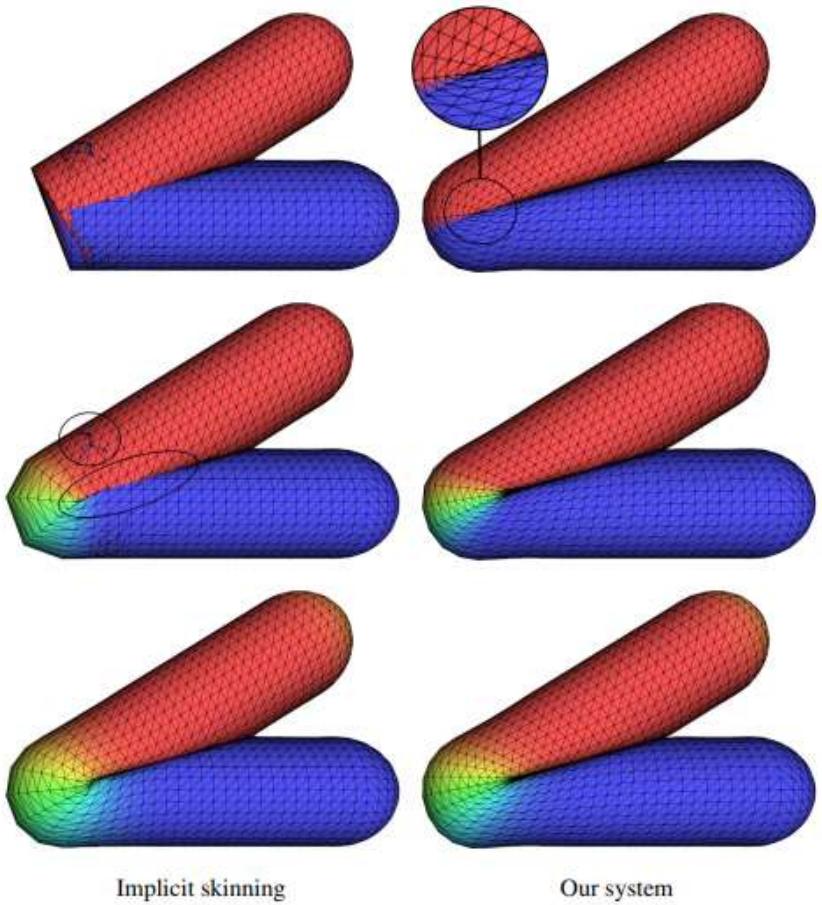
Painting parts deformed  
with geometric skinning

# Results: skin elasticity



Painting parts deformed  
with geometric skinning

# Results: skin elasticity



# Results: skin elasticity

