

CS 523: Computer Graphics, Spring 2009

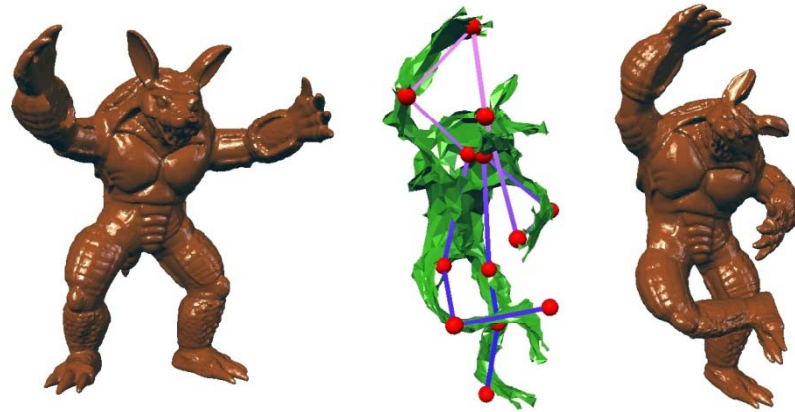
Shape Modeling

Shape deformation intro

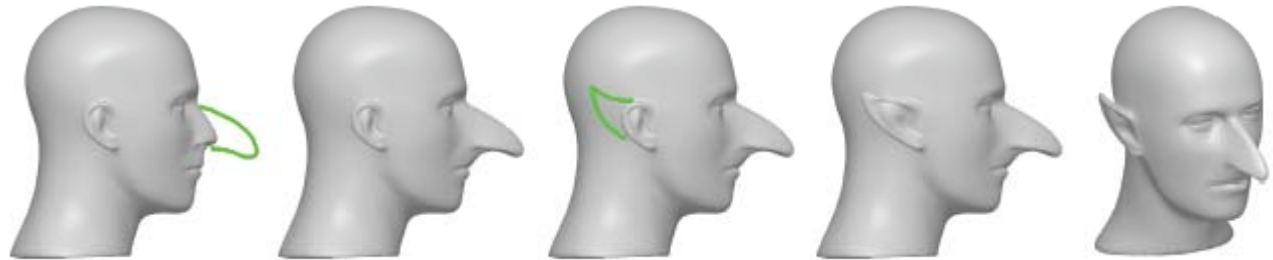
Surface vs. space deformations

Why shape deformation?

- Animation



- Editing



- Simulation



Parametric curves and surfaces

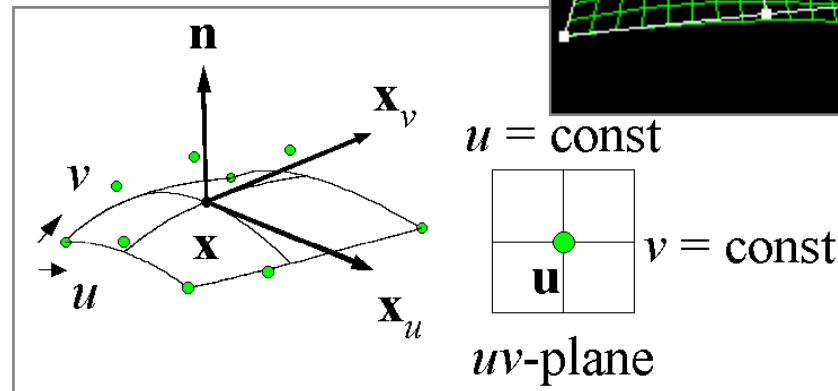
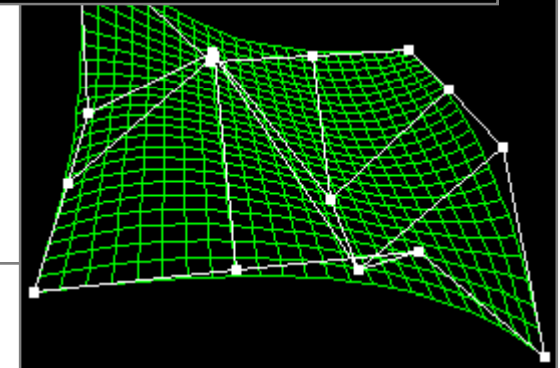
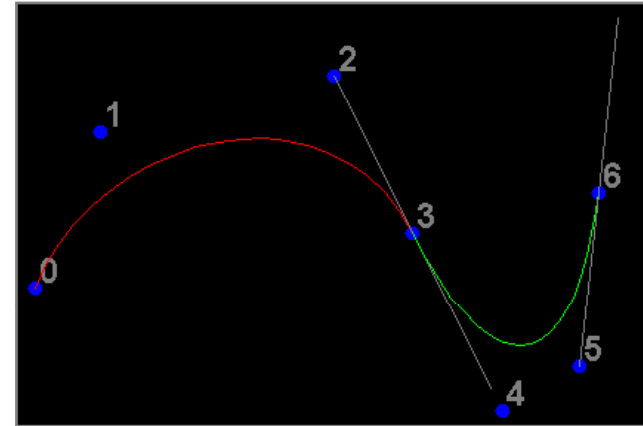
Deformation by control point manipulation

- Some online demos

- <http://www.cs.princeton.edu/~min/cs426/jar/bezier.html>

- <http://www.nbb.cornell.edu/neurobio/land/OldStudentProjects/cs490-96to97/anson/BezierPatchApplet/>

- <http://wwwvis.informatik.uni-stuttgart.de/~kraus/LiveGraphics3D/cagd/>



Mesh/shape deformation

Basic idea

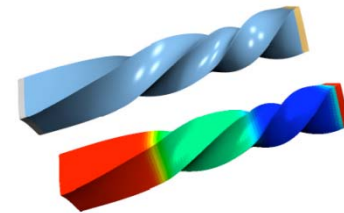
- Naïve method: dragging single vertices
 - One by one, or Rigid/affine (linear) transformation of vertex groups
- Smarter:
 - Create a small set of control parameters (reminder: *face* spaces)
 - Introduce a small set of deformation handles
 - Makes deformation editing easier
 - Introduces a trade-off between degrees of freedom and simplicity of the deformation task

Mesh/shape deformation

Commonly used paradigms

- **Surface based deformation**

- Laplacian surface editing and other surface-based energy minimization approaches
- Physically motivated:
Laplacian preservation \approx bending resistance



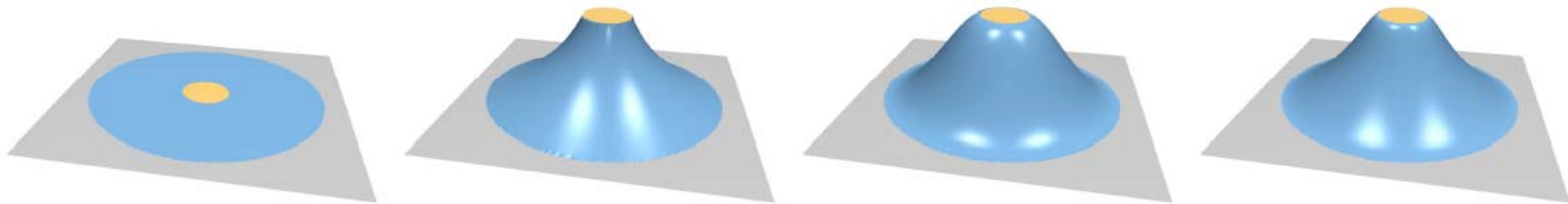
- **Space deformation**

- Deforms some 2D/3D space using a *cage*
- Deformation propagation to all points in the space
- Independent of shape representation

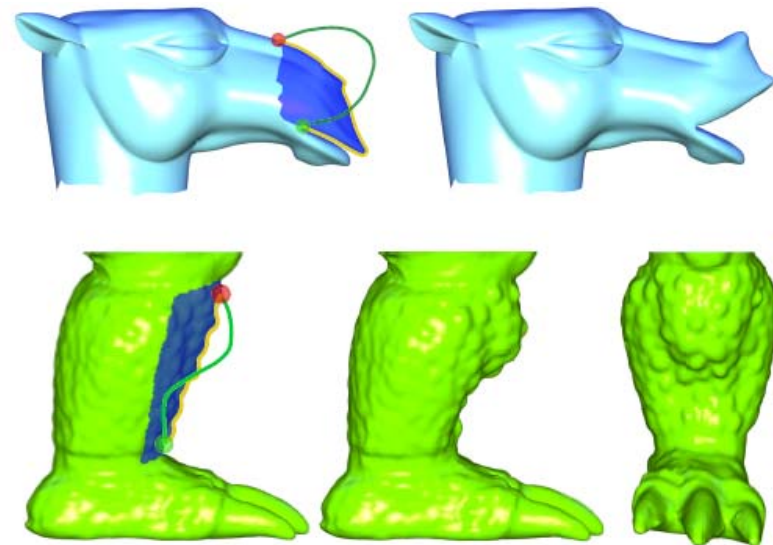
Surface-based deformations

Examples

- Region of interest (ROI) + affine deformation handle with variable boundary continuity



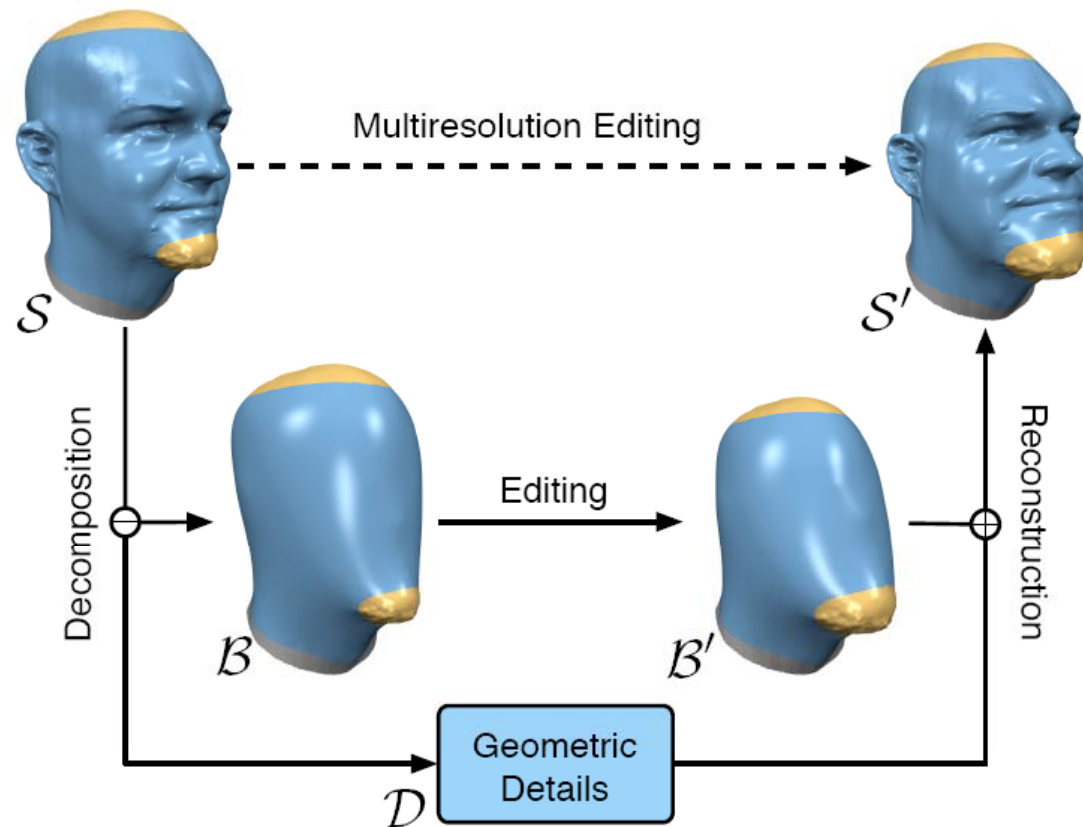
- Intuitive sketch-based deformation interfaces



Surface-based deformations

Examples

- Multi-resolution mesh editing



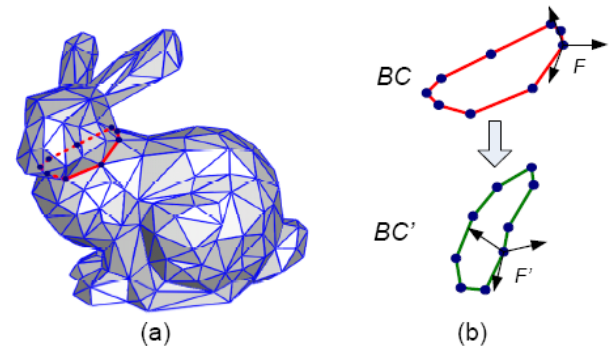
Surface-based deformations

Linear methods

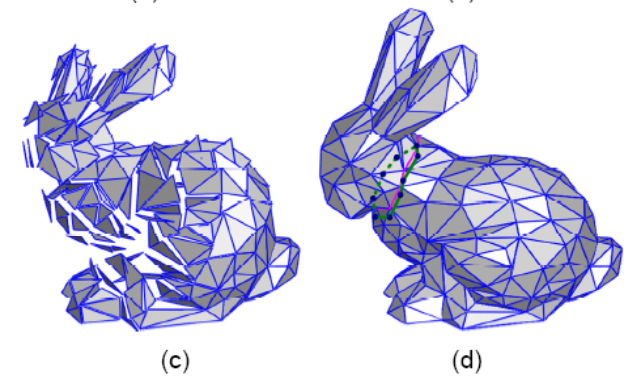
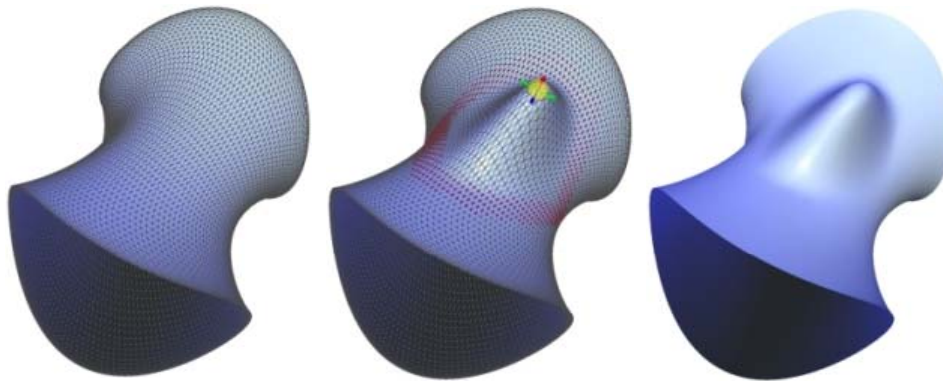
- (2D) As rigid as possible shape manipulation



- Triangle gradient methods



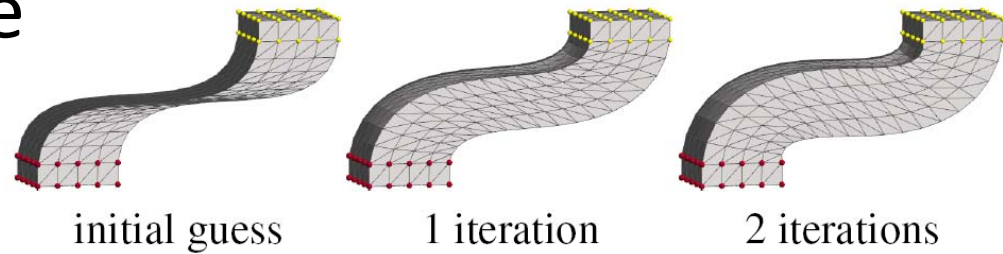
- Laplacian surface editing



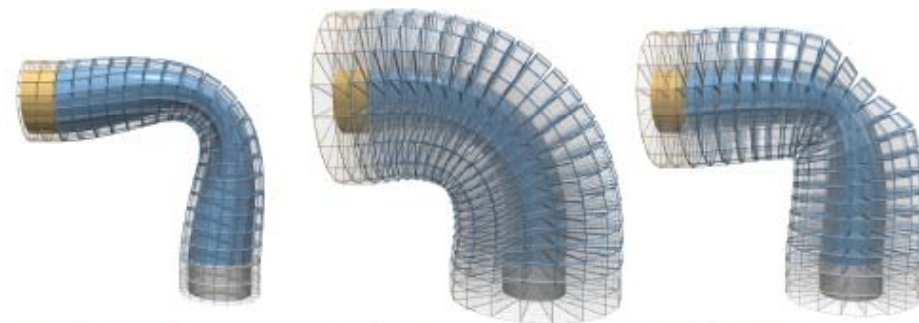
Surface-based deformations

Nonlinear methods

- As rigid as possible surface modeling



- PriMo



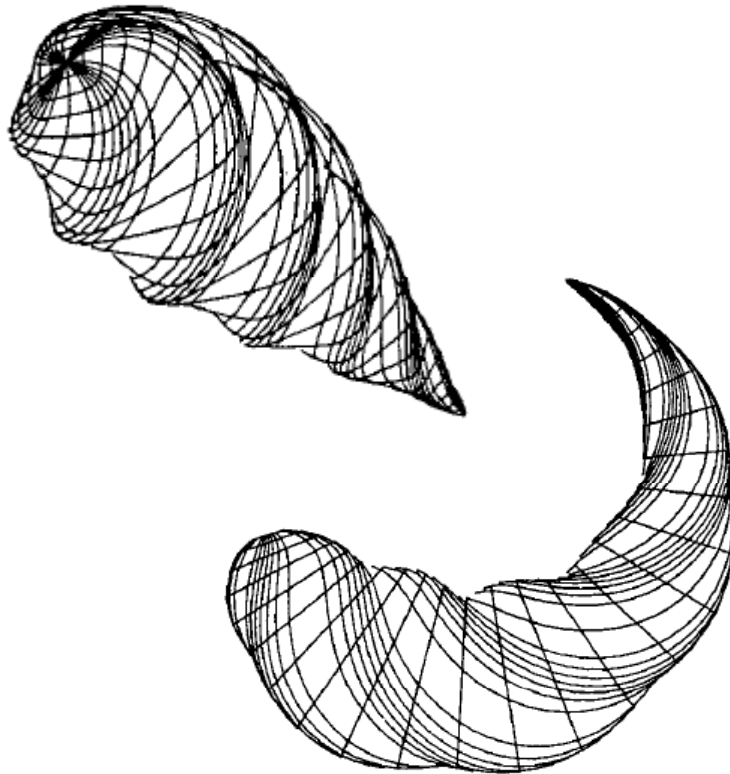
- Mesh Puppetry



Space deformations

Early seminal work in computer graphics

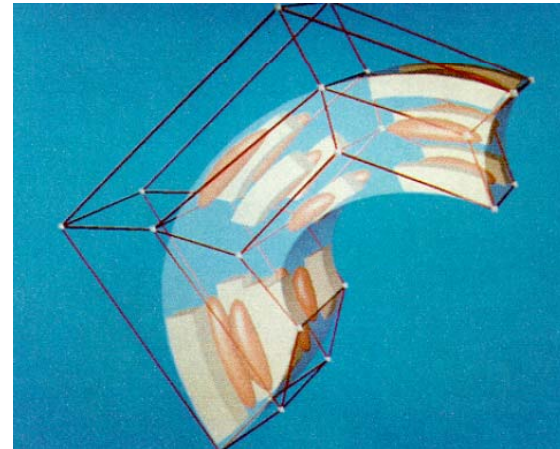
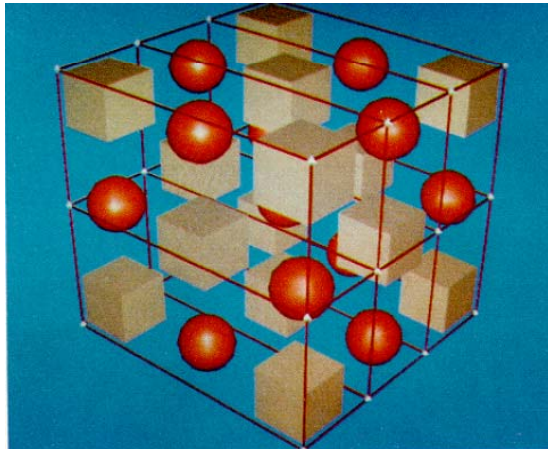
- Global and local deformation of solids [Barr 1984]



Space deformations

Early seminal work in computer graphics

- Free form deformations [Sederberg and Parry 1986]
 - Uses trivariate tensor product polynomial basis



- Can be designed to be volume preserving



$$\mathbf{F}(x,y,z) = (F(x,y,z), G(x,y,z), H(x,y,z))$$

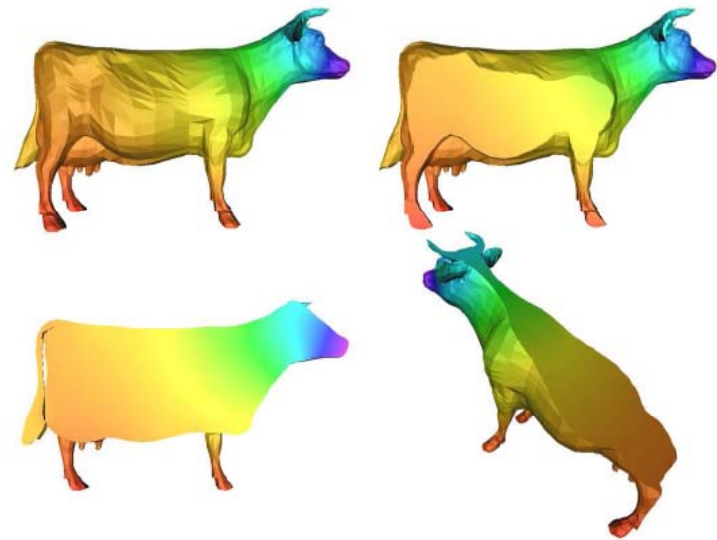
then the Jacobian is the determinant

$$Jac(\mathbf{F}) = \begin{vmatrix} \frac{\partial F}{\partial x} & \frac{\partial F}{\partial y} & \frac{\partial F}{\partial z} \\ \frac{\partial G}{\partial x} & \frac{\partial G}{\partial y} & \frac{\partial G}{\partial z} \\ \frac{\partial H}{\partial x} & \frac{\partial H}{\partial y} & \frac{\partial H}{\partial z} \end{vmatrix}$$

Space deformations

Basic idea

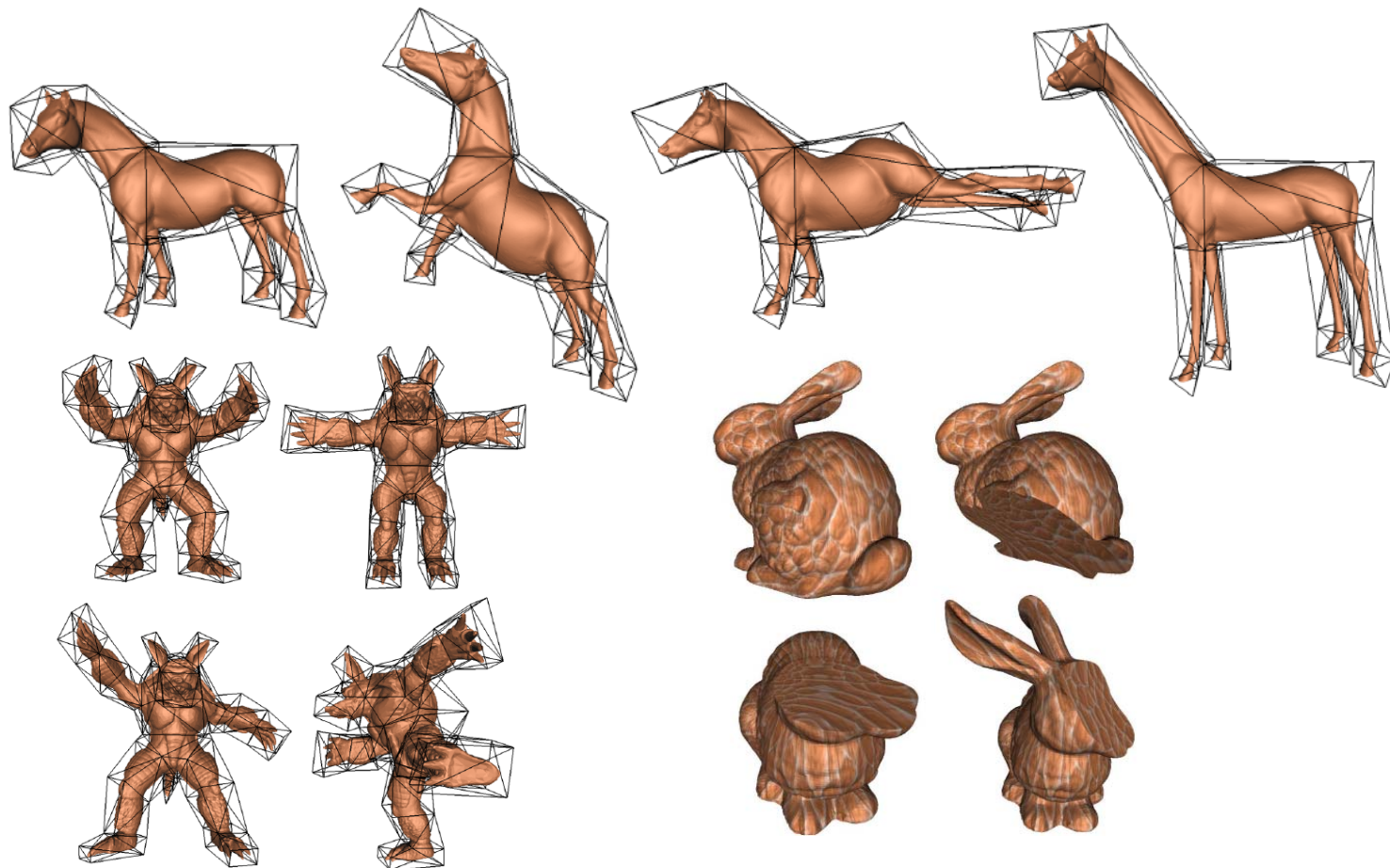
- Design a set of coordinates for all points in \mathbb{R}^n w.r.t. the cage vertices
 - Each point \mathbf{x} can be represented as a weighted and normalized sum of cage points
 - The coordinates are smoothly varying and guarantee continuity inside the volume



Space deformations

Examples

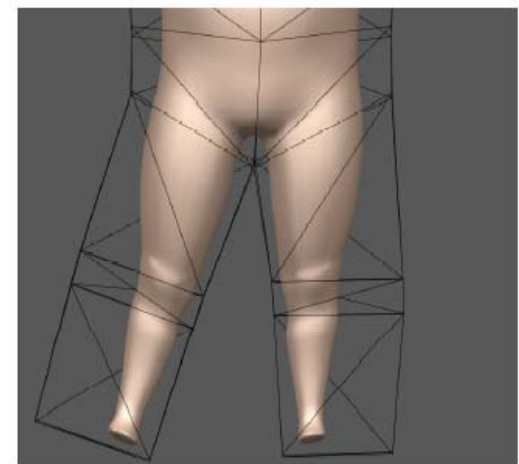
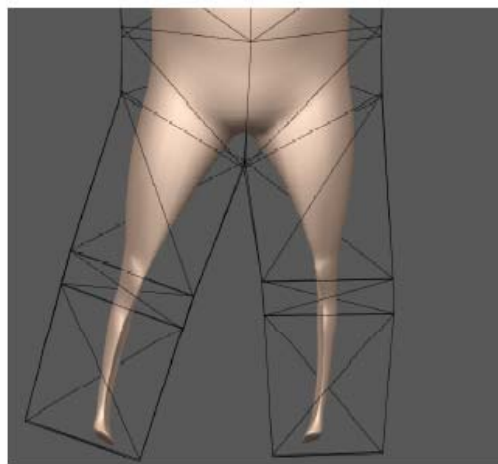
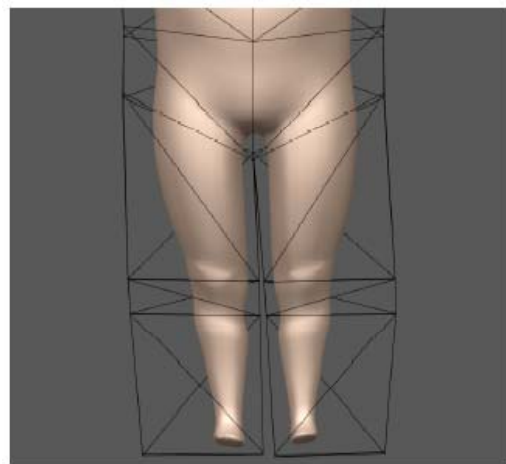
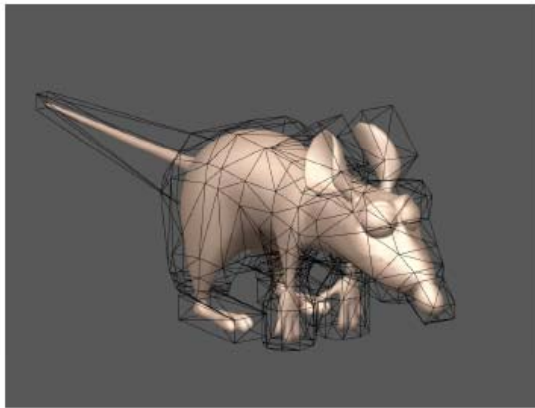
- Mean value coordinates for closed tri meshes



Space deformations

Examples

- Harmonic coordinates



Space deformations

Examples

- Green coordinates

