Digital Geometry
- Shape Deformations

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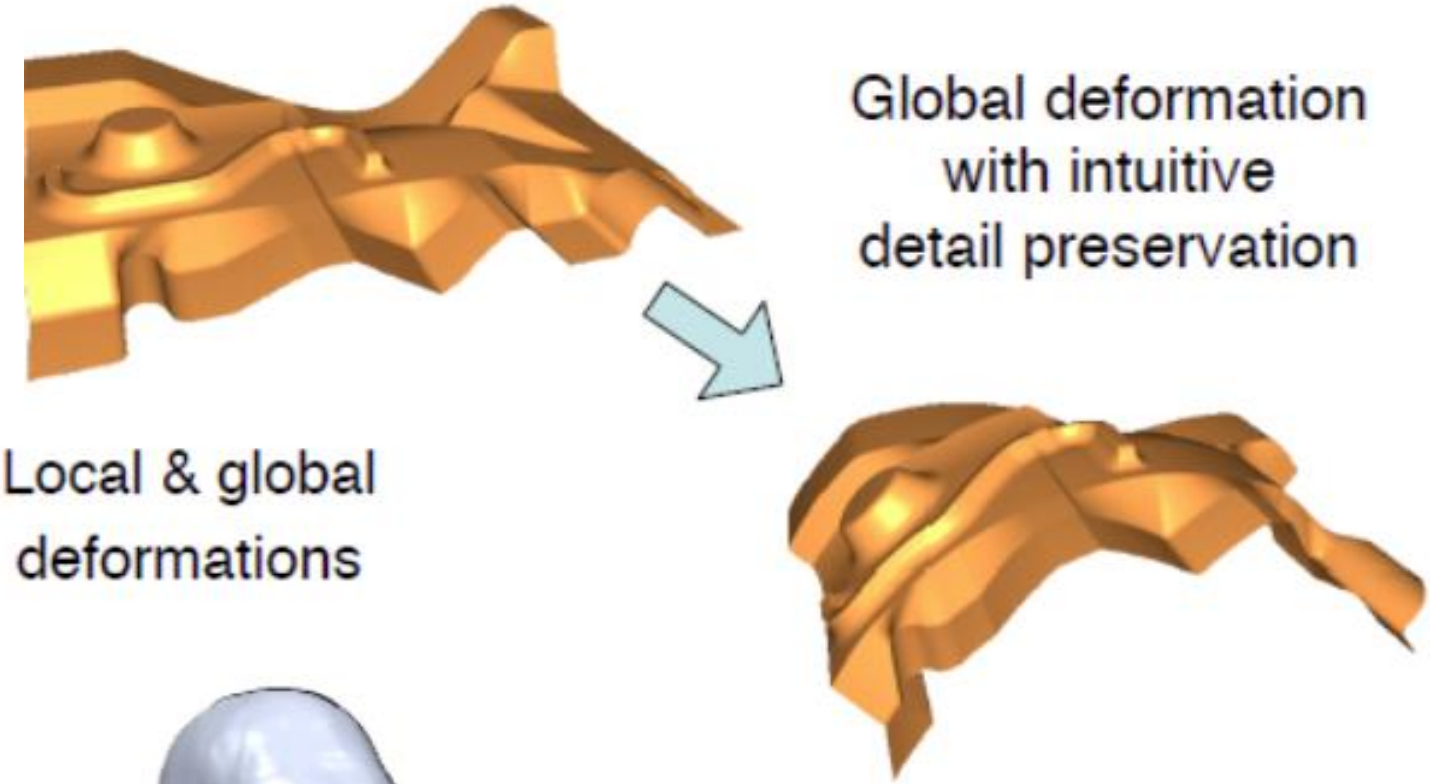
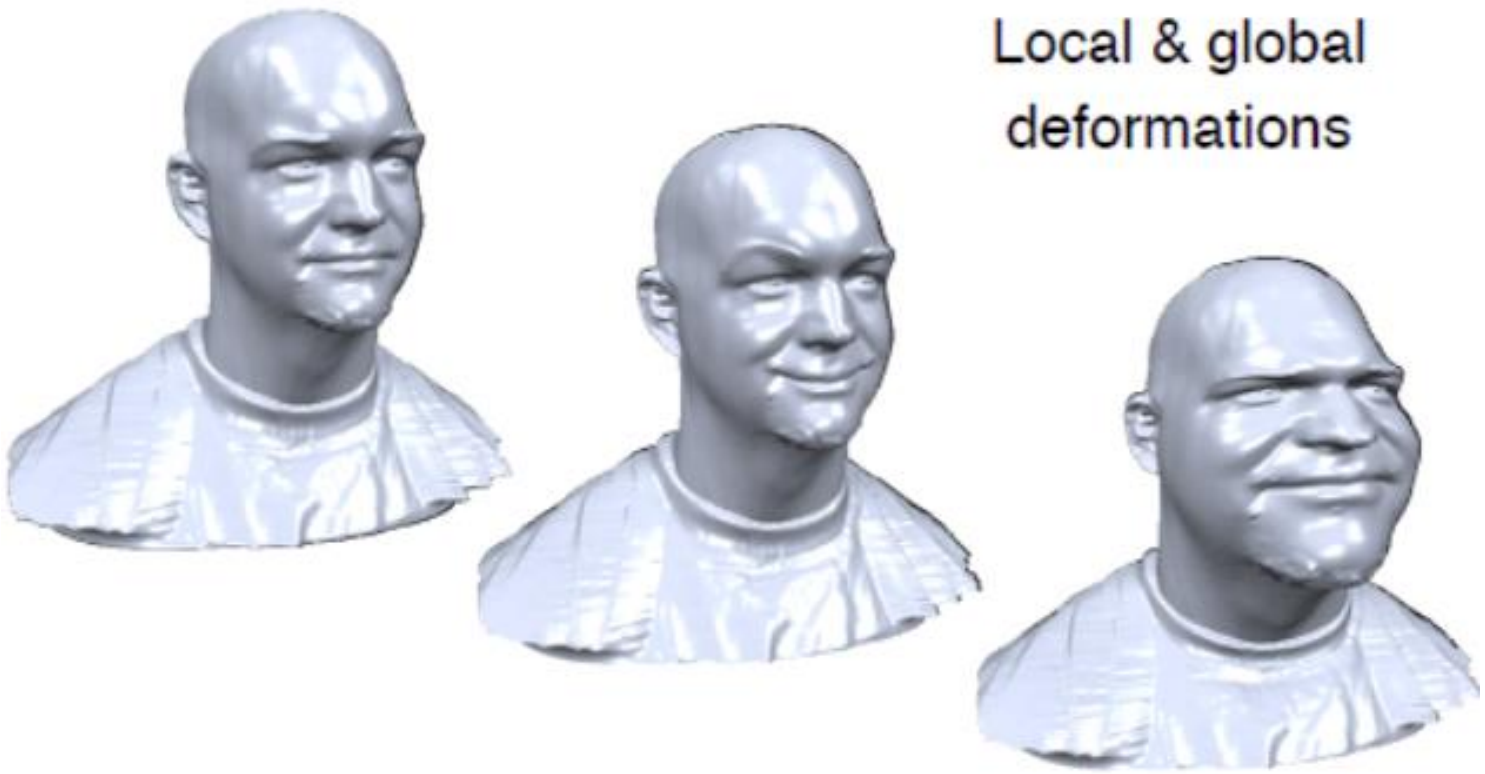
http://jjcao.github.io/DigitalGeometry/

Pleasure may come from illusion, but happiness can come only of reality.

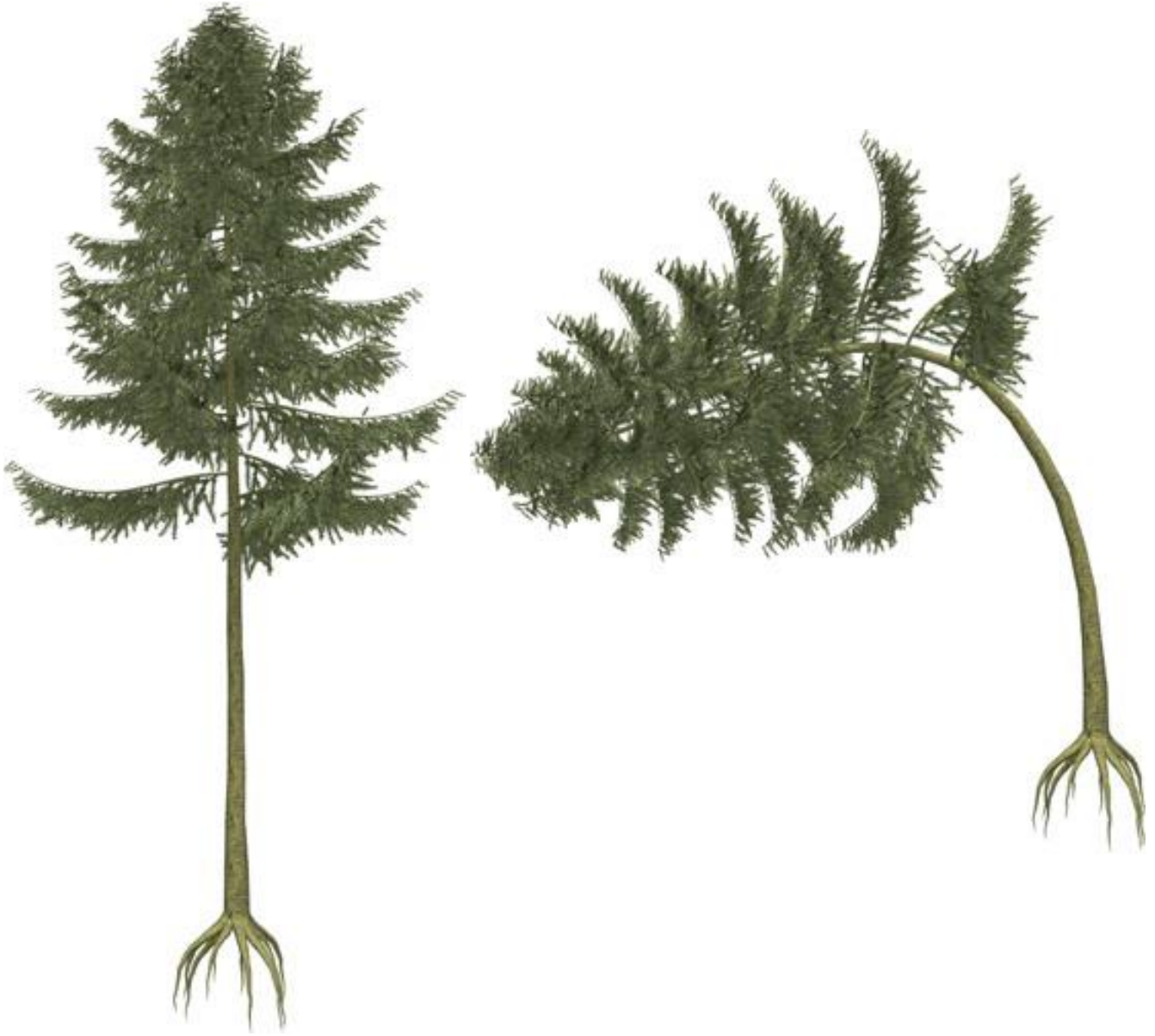
Local & global deformations



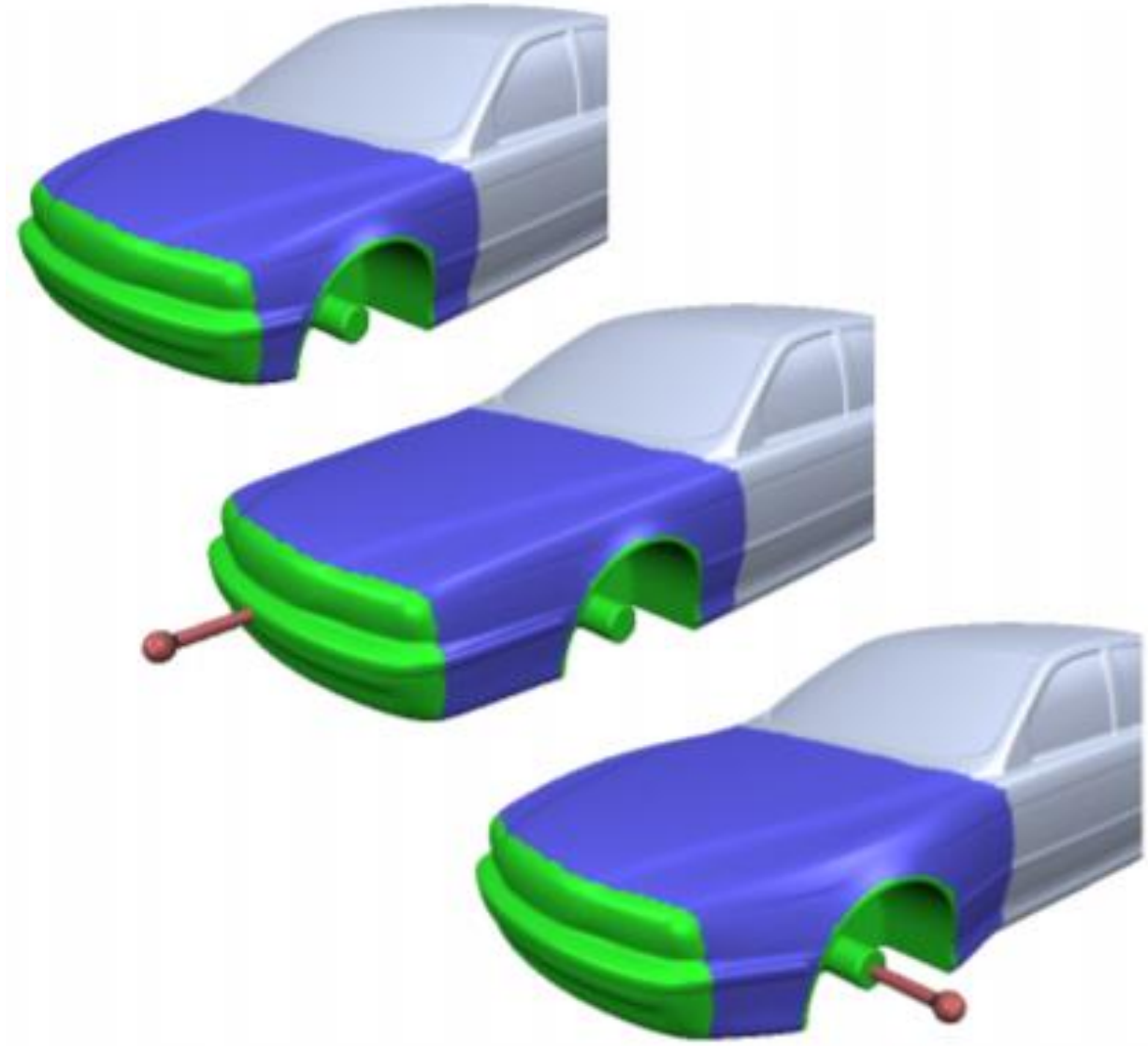
Local & global
deformations



Editing of complex meshes



CAD-Like Deformation

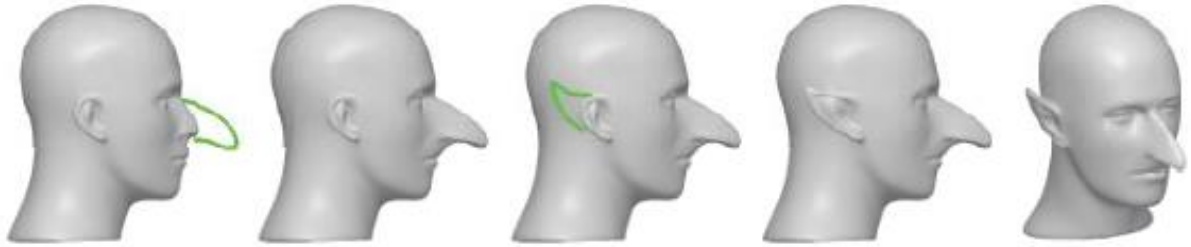


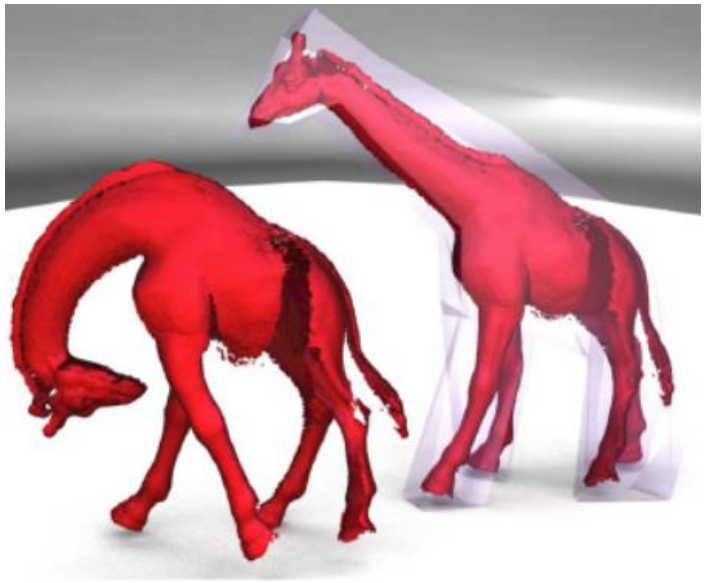
How to deform?

- To deform a model, move its control points
- The rest follows …

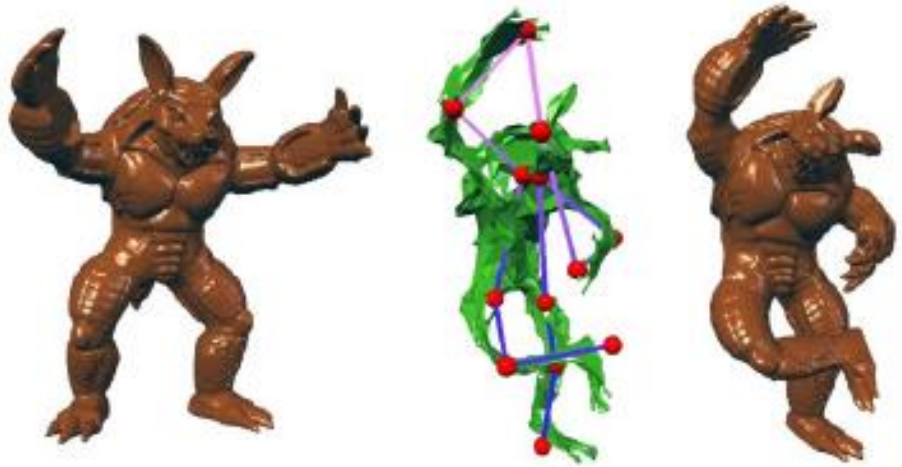
Motivation

- Easy modeling – generate new shapes by editing existing ones





- Character posing for animation



- Simulation

Criteria?

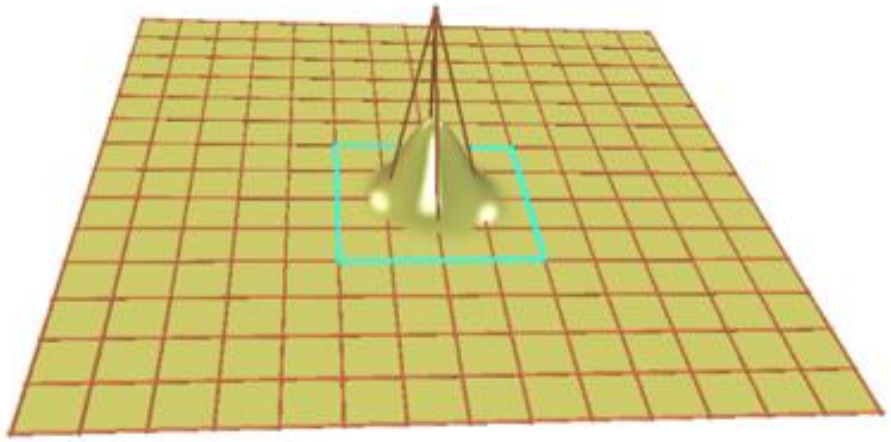
- Intuitive behavior and interface
- semantics
- Interactivity

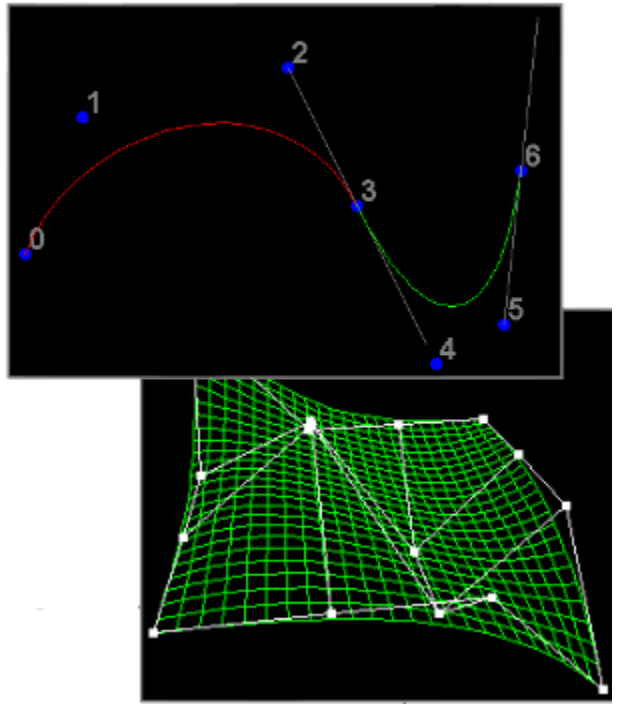
Parametric curves and surfaces

Deformation by control point manipulation

- **Tensor product surfaces (“curves of curves”)!**
  - Rectangular grid of control points

$$\mathbf{p}(u,v) = \sum_{i=0}^{k} \sum_{j=0}^{l} \mathbf{p}_{ij} N_i^n(u) N_j^n(v)$$

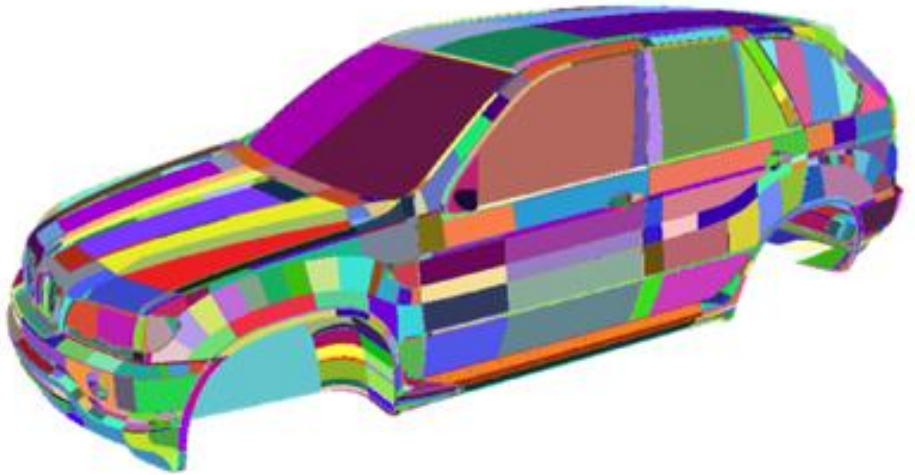




Spline Surfaces

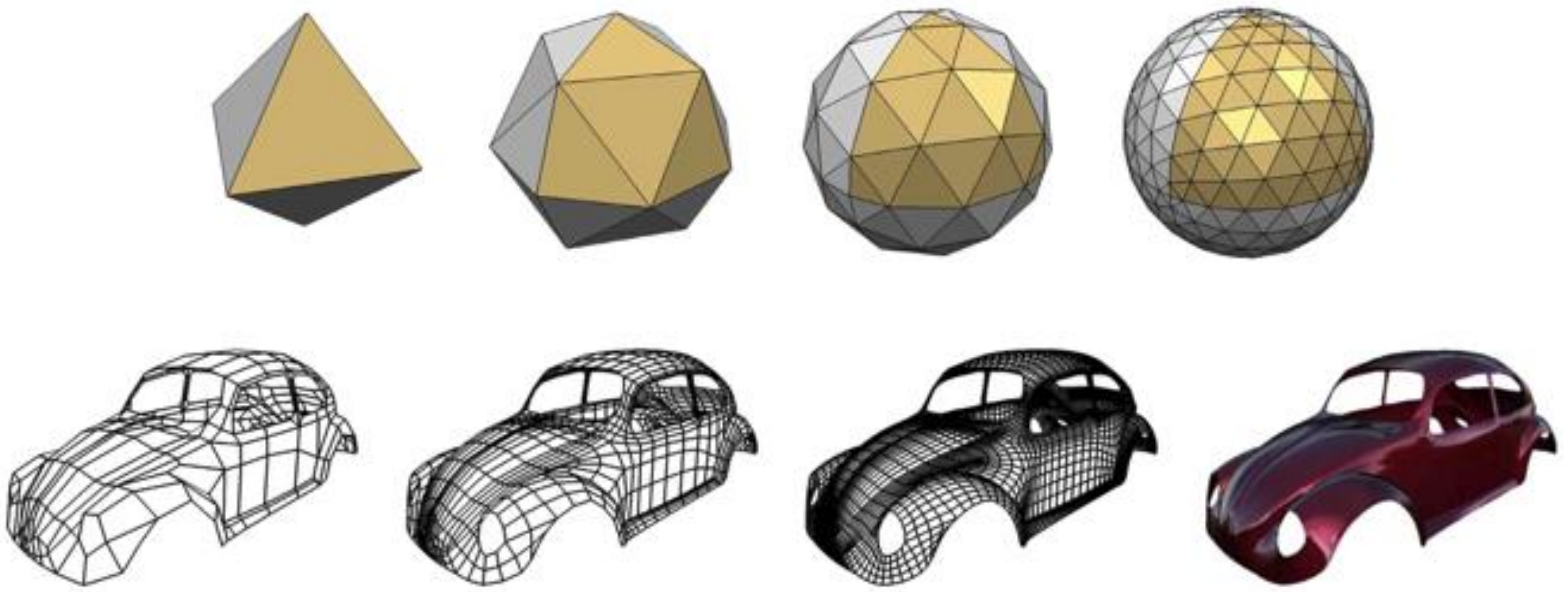
- **Tensor product surfaces (“curves of curves”)!**
  - Rectangular grid of control points
  - Rectangular surface patch

- **Problems:**
  - Many patches for complex models
  - Smoothness across patch boundaries
  - Trimming for non-rectangular patches



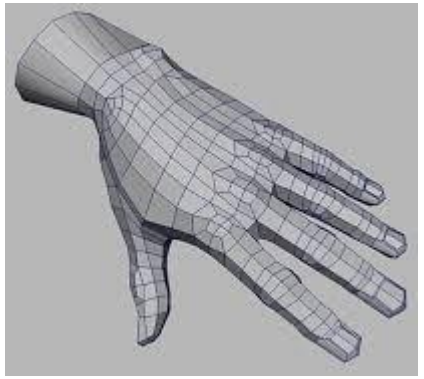
Subdivision Surfaces

- **Generalization of spline curves/surfaces!**
  - Arbitrary control meshes
  - Successive refinement (subdivision)
  - Converges to smooth limit surface
  - Connection between splines and meshes

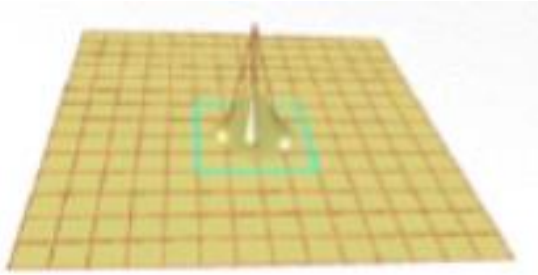


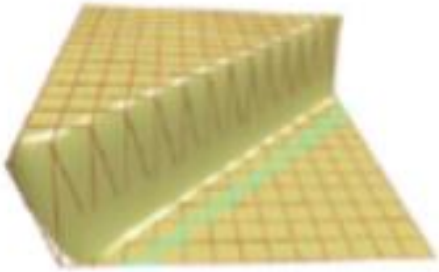
Spline & Subdivision Surfaces

- **Basis functions are smooth bumps!**
  - Fixed support
  - Fixed control grid

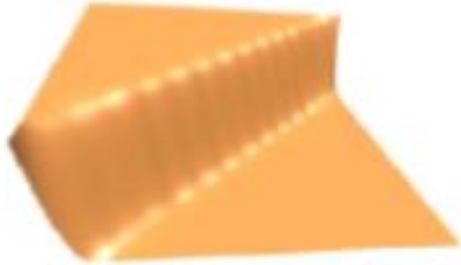


- **Bound to control points!**
  - **Initial** patch **layout** is crucial
  - Requires experts!



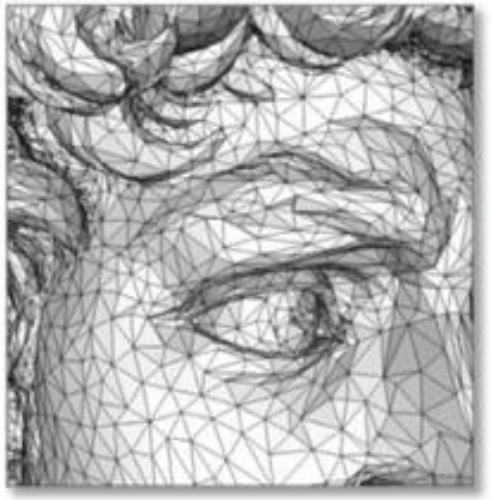


- **De-couple deformation from surface representation!**

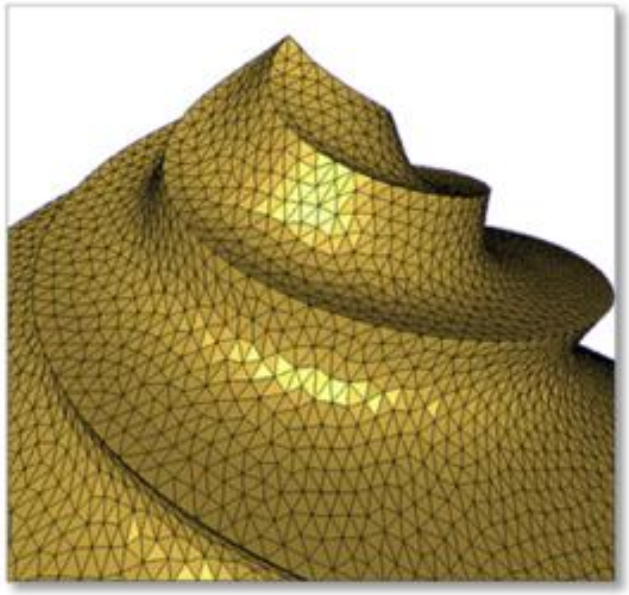


Discrete Surfaces: Point Sets, Meshes

- Flexible
- Suitable for highly detailed scanned data
- No analytic surface
- No inherent “editability”



- Mesh Editing



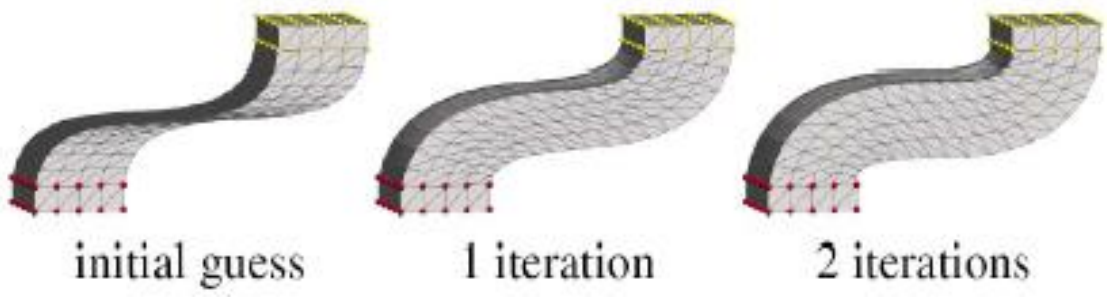
Classifications

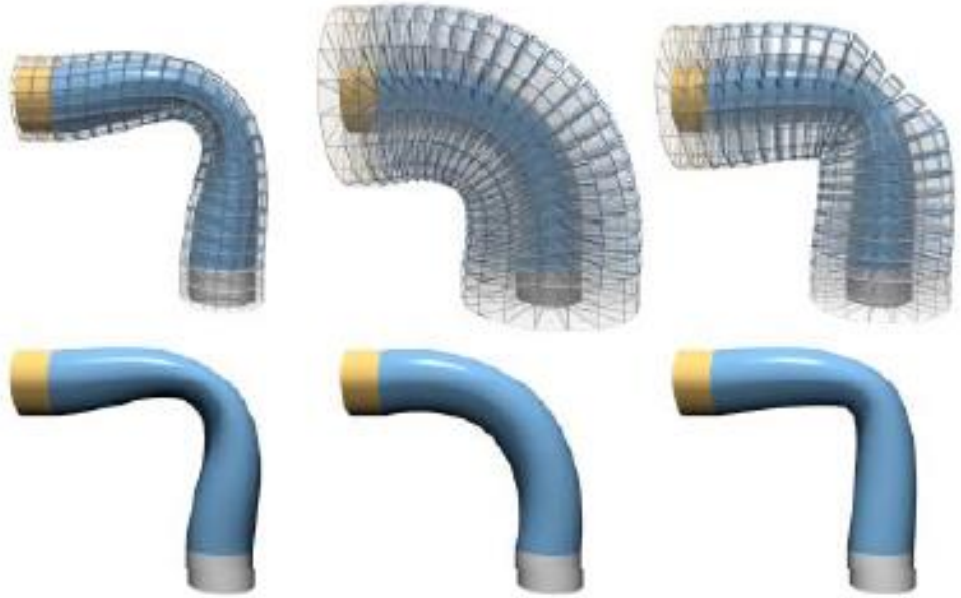
- **Surface-based deformation**
  - **Energy minimization**
  - Multiresolution editing
  - Differential coordinates
- Space deformation
  - Freeform deformation
  - Energy minimization
- Linear vs. nonlinear methods

Surface-based deformations

Nonlinear methods

- As rigid as possible surface modeling
- Prism-based modeling
- Mesh Puppetry



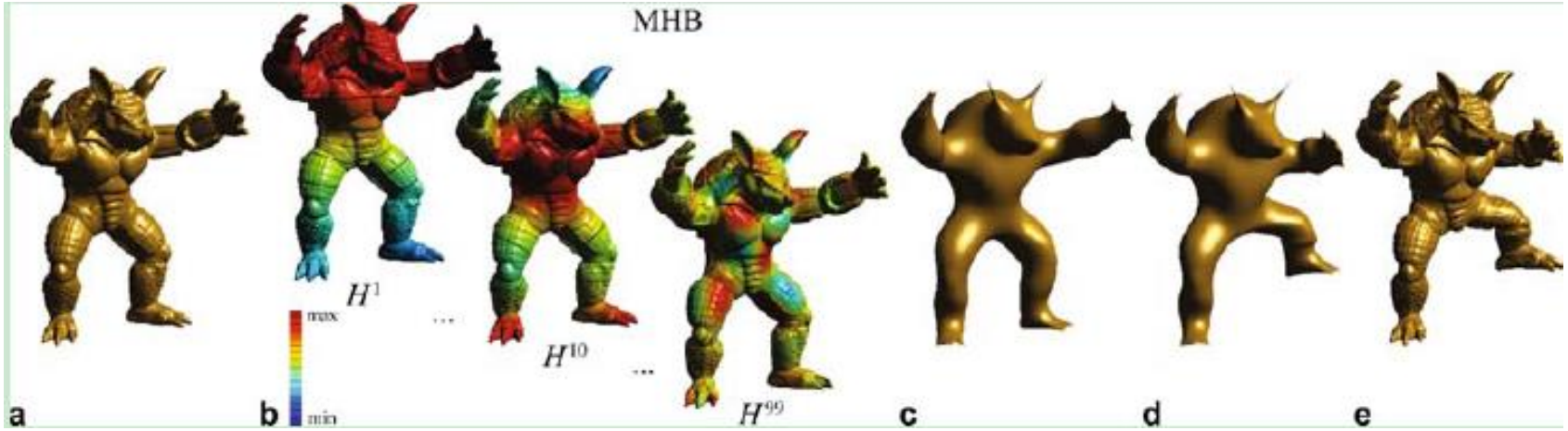


Surface deformations
Summary

- Objective functional in the mesh elements (vertices)
- Complexity depends on the mesh size
- Linear methods:
  - Solve a global linear system on the mesh
  - Usually suffer from some artifacts
- Nonlinear methods
  - Fewer artifacts but slower, and harder to implement

Spectral Mesh Deformation

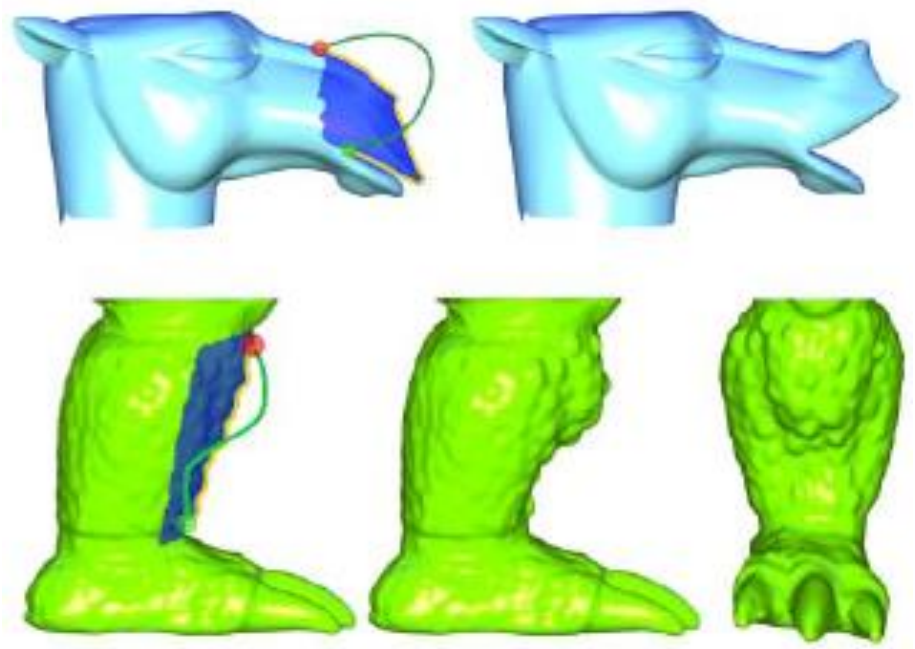
- Build a smoothed mesh *using* manifold harmonics transform
- Deform the smoothed mesh,
- Add the details back using deformation transfer



[spectral mesh deformation]

[Spectral Surface Deformation with Dual Mesh]

Intuitive sketch-based deformation interfaces



Space Deformations, Surface Deformations and the Opportunities In-Between

Various handles

- Interaction GUI?

Software

- Maya
- 3D Max
- Z-Brush

References

- Olga Sorkine, Geometric Modeling - G22.3033-008

Thanks