Hierarchical Deformation of Locally Rigid Meshes

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• Simplified control of deformation





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- Fast feedback

Auxiliary Controls

Skeletons





Auxiliary Controls



Fig. 6 Undeformed Polygons



Fig. 7 Deformed Polygons



[Sederberg and Parry 1986]

Auxiliary Controls

Cages



[Ju et al. 2005]

[Joshi et al. 2007]

Subdivision control mesh





[Catmull and Clark 1978]

Thin shell simulation



[Botsch et al. 2006]

[Sorkine and Alexa 2007]

Volumetric simulation



[Mezger et al. 2007]

Vibrational modes



[Hildebrandt et al. 2012]

Our Solution

- Simplify the mesh
- Perform physical simulation
- Add details conforming to the simulation

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Edge Collapse Metric

Distance to planes

Distance to points

Edge Collapse Metric

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As-rigid-as-possible surface modeling
 [Sorkine and Alexa 2007]

- As-rigid-as-possible surface modeling
 [Sorkine and Alexa 2007]
- Added ability to satisfy constraints not at mesh vertices

 $\min_{q_i, R_i R_i^T = I} \sum_{j \in \mathcal{N}(p_i)} \int_s \int_t |(q_j(s, t) - q_i) - R_i(p_j(s, t) - p_i)|^2 dt ds$

As-rigid-as-possible Deformation

$$\min_{\substack{R_i R_i^T = I}} \sum_{j \in \mathcal{N}(p_i)} \int_s \int_t |(q_j(s,t) - q_i) - R_i(p_j(s,t) - p_i)|^2 dt ds$$

$$\min_{\substack{q_i \ j \in \mathcal{N}(p_i)}} \sum_{j \in \mathcal{N}(p_i)} \int_s \int_t |(q_j(s,t) - q_i) - R_i(p_j(s,t) - p_i)|^2 dt ds$$

 $E_{c} = \sum_{i} \sum_{k} |(d_{k} - q_{i}) - R_{i}(c_{k} - p_{i})|^{2}$

Adding Details Constrained

• Deform local neighborhood before expansion

Adding Details Constrained

$$E_{x} = \sum_{k} |(d_{k} - \bar{q}) - R_{c}(c_{k} - \bar{p})|^{2}$$

Adding Details Constrained

Results

Low-res simulation (1.4 ms/f)

Different Transforms

Rigid

Similarity

Stretch

Conclusion

- Calculate deformation at low resolution
- Expand to high resolution
 - As-rigid-as-possible, satisfy constraints
 - Use a local, symmetric expansion operation
- Combine with other methods
 - Different deformation of base mesh
 - As-similar-as-possible, tangential stretch

Multiresolution Signal Processing for Meshes

(a) MSPM

(b) Rigid

