A Sketch-Based Interface for Detail-Preserving Mesh Editing

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Ideas and Contributions

- **A sketch-based interface...**
  - Feature modification
    (object-space silhouettes)
  - Feature creation
    (sharp features, ridges, ravines)

- **... For detail-preserving mesh editing**
  - Adjust remaining geometry around the modified/created feature such that shape characteristics are preserved
Sketch-Based Interfaces and Modeling

- Previous work
  - SKETCH [Zeleznik et al. 96]
  - Teddy [Igarashi et al. 99 and 03]
  - Variational implicits [Karpenko et al. 02]
  - Relief [Bourguignon et al. 04]
  - Sketching mesh deformations [Kho]
  - Parametrized objects [Yang et al. 05]
Mesh Modeling Framework 1/4

- Satisfy linear modeling constraints
- Preserve local detail after imposing editing constraints.
Mesh Modeling Framework 2/4

- Preserve the Laplacian of the original geometry, $G = (V, E)$, in the least squares sense.

$$V' = \arg \min_w \| \Delta V - \Delta W \|^2$$

- Equivalent to solving a linear system in the least squares sense.

$$AV' = b \quad \Rightarrow \quad A^T AV' = A^T b$$
Constraints:

- Operations are restricted to ROI. The anchor vertices keep their positions: $v'_i = v_i$
- Relative positions of points on edges and inside triangles are preserved.
- Set restrictions on the normal direction and the resulting curvature.
Mesh Modeling Framework}

- $\delta_i$ is the Laplacian of vertex $v_i$

$$\delta_i = v_i - \sum_{\{i,j\} \in E} w_{ij} v_j$$

- $\delta_{\text{cotangent}} : w_{ij} = \cot \alpha_{ij} + \cot \beta_{ij}$

- $\delta_i$ points in the normal direction and $||\delta_i||$ is proportional to the mean curvature around vertex $i$

$\implies$ add constraints: $v'_j - \sum_{\{i,j\} \in E} w_{ij} v'_j = \delta'_i$
The Possibilities

- Silhouette Sketching
- User-Defined Sketching
- Sharp Features
- Suggestive Contours
Silhouette Sketching

- Using silhouettes as handles
  - Detect silhouette as polyline with vertices $q_i$
  - Project vertices to screen space and parametrize over $[0,1]$
  - Represent sketch as polyline with vertices $s_i$ and parametrize over $[0,1]$
  - Find correspondences and define a new screen space position $q_i$
  - Use $q_i$ as positional constraints while retaining depth value
  - The weighting of positional constraints along the silhouette determine the final position.
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Silhouette Sketching

- Approximate sketching
  - Balance weighting between detail and positional constraints
Silhouette Sketching

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Approximate sketching

- Weighting the positional constraints retains the surface characteristics.
User-Defined Sketching

- We wish to influence (discrete) differential properties of the mesh for arbitrary sketches defined by the user.

- The solution
  - Adjust mesh geometry to lie under the sketch (as seen from the camera), while preserving mesh topology and ensuring well shaped triangles.
Geometry Adjustment

- First: **min cost edge path (close to sketch)**
Geometry Adjustment

- Second: projection onto sketch
Geometry Adjustment

- Second: **projection onto sketch**
  - Approximates the sketch very well
  - Can introduce skinny triangles
Geometry Adjustment

- Third: **local mesh regularization**
  - Improve triangle shapes by relaxing vertices closed to the sketch so that their umbrella Laplacian equals the cotangent Laplacian.

\[ A \mathbf{v} = \delta \]
Geometry Adjustment

- Third: **local mesh regularization**
  - Well shaped triangles and nice piecewise linear approximation of the users sketch
Sharp Features

- Edit: *scale (or add to) Laplacians*
Sharp Features

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Suggestive Contours
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Conclusions

- **Avantages**
  - Intuitive, easy to use, sketch-based User Interface for silhouette deformation and feature creation/modification.
  - Preserves surface detail as much as possible.

- **Disadvantages**
  - The update time is proportional with the number of vertices in ROI.
  - Doesn’t work on noisy surfaces.
  - Editing differential properties can take time to learn.
Thank You!