Overview

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  - Editing Operators
- Summary

PointShop3D

- Interactive system for point-based surface editing
- Generalizes 2D photo editing concepts and functionality to 3D point-sampled surfaces
- Uses 3D surface pixels (surfels) as versatile display and modeling primitive

Key Components

- Point cloud parameterization $\Phi$
  - brings surface and brush into common reference frame
- Dynamic resampling $\Psi$
  - creates one-to-one correspondence of surface and brush samples
- Editing operator $\Omega$
  - combines surface and brush samples

Parameterization

- Constrained minimum distortion parameterization of point clouds

$$\mathbf{u} \in [0,1]^2 \Rightarrow X(\mathbf{u}) = \begin{bmatrix} x(\mathbf{u}) \\ y(\mathbf{u}) \\ z(\mathbf{u}) \end{bmatrix} = \mathbf{x} \in P \subset R^3$$
Parameterization

- Constraints = matching of feature points
- Minimum distortion = maximum smoothness

Parameterization

- Find mapping $X$ that minimizes objective function:
  $$C(X) = \sum_{j \in M} (X(p_j) - x_j)^2 + \epsilon \int_P \gamma(u) du$$

Parameterization

- Measuring distortion
- Integrates squared curvature using local polar re-parameterization
  $$X_u(\theta, r) = X(u + r \left[ \cos(\theta) \right]_i)$$

Parameterization

- Discrete formulation:
  $$\tilde{C}(U) = \sum_{j \in M} (p_j - u_j)^2 + \epsilon \sum_{i \in Nj} \left( \frac{\partial U(x_i)}{\partial u_j} - \frac{\partial U(x_l)}{\partial u_j} \right)^2$$
  - Approximation: mapping is piecewise linear

Parameterization

- Directional derivatives as extension of divided differences based on k-nearest neighbors

Parameterization

- Multigrid solver for efficient computation of resulting sparse linear least squares problem
  $$\tilde{C}(U) = \sum_j \left( b_j - \sum_i \alpha_{ij} u_i \right)^2 = \| b - Au \|_2^2$$
Reconstruction

- Parameterized scattered data approximation
  \[ X(u) = \sum_i \Phi_i(u) \cdot r_i(u) \]
  \[ \sum_i \Phi_i(u) = 1 \]
- Fitting functions
  - Compute local fitting functions using local parameterizations
  - Map to global parameterization using global parameter coordinates of neighboring points

Reconstruction

- Reconstruction with linear fitting functions is equivalent to surface splatting!
  - we can use the surface splatting renderer to reconstruct our surface function (see chapter on rendering)
- This provides:
  - Fast evaluation
  - Anti-aliasing (band-limit the weight functions before sampling using Gaussian low-pass filter)
  - Distortions of splats due to parameterization can be computed efficiently using local affine mappings

Sampling

- Three sampling strategies:
  - Resample the brush, i.e., sample at the original surface points
  - Resample the surface, i.e., sample at the brush points
  - Adaptive resampling, i.e., sample at surface or brush points depending on the respective sampling density

Editing Operators

- Painting
  - Texture, material properties, transparency

Editing Operators

- Sculpting
  - Carving, normal displacement
**Editing Operators**

- Filtering
  - Scalar attributes, geometry

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**Summary**

- **Pointshop3D** provides sophisticated editing operations on point-sampled surfaces
- Points are a versatile and powerful modeling primitive
- Limitation: only works on “clean” models
  - Sufficiently high sampling density
  - No outliers
  - Little noise
  - Requires model cleaning (integrated or as pre-process)

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**Reference**

- Zwicker, Pauly, Knoll, Gross: *Pointshop3D: An Interactive system for Point-based Surface Editing*, SIGGRAPH 2002
  - Check out: [www.pointshop3D.com](http://www.pointshop3D.com)