Mesh Smoothing based on Anisotropic Mean Curvature Flow

Phan-Anh Nguyen[1]

[1]Chair of Computer Graphics & Multimedia
RWTH-Aachen University

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Outline

Remove noise from 3D scaners

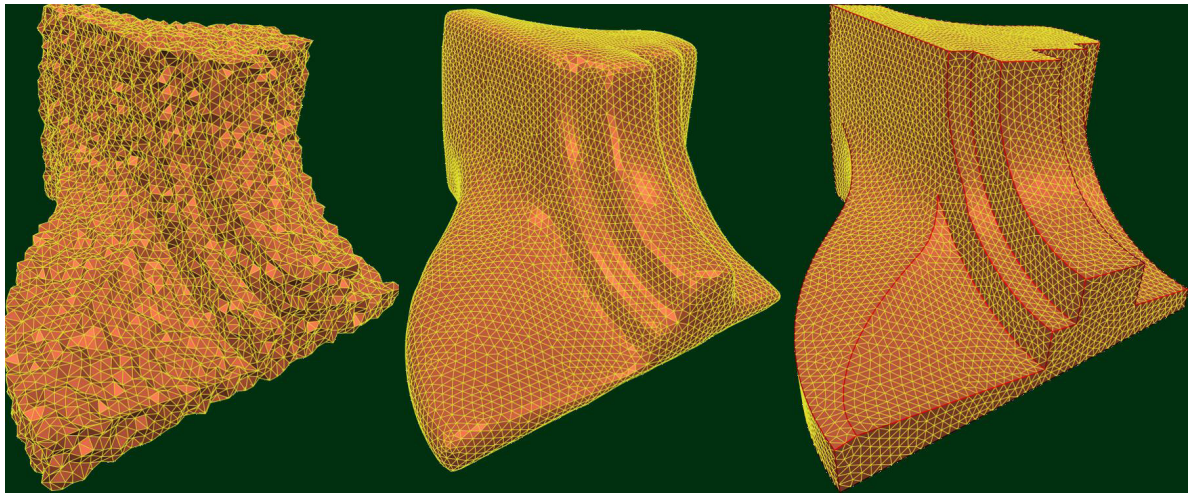


Figure : Remove noise with/without feature preservation

- Various techniques
  - Laplacian operator: does not preserve sharp edges
  - bilateral filter: preserves sharp edges
  - anisotropic prescribed mean curvature flow: preserves sharp curves

Mean Curvature

- Smooth: reduce curvature (or area gradient)

$$\bigtriangledown_p \, area \, M = \vec{H}(p) = 1/2 \sum_{q_i \in \, link \; p} (cot\alpha_{q_i} + cot\beta_{q_i})(p - q_i)$$

- Define $\vec{H}(e) = H_e \vec{N}_e$, where $\vec{N}_e$ is edge normal and $H_e = 2|e|cos(\theta_e/2)$ is edge mean curvature then:

$$\vec{H}(p) = 1/2 \sum_{e=(p,q), q \in link \; p} \vec{H}(e)$$

Anisotropic Mean Curvature

- Weight less for feature vertices to avoid smoothing sharp features

$$\vec{H}_A(p) = 1/2 \sum_{e=pq, q \in link\ p} w(H_e) H_e \vec{N}(e)$$

$$w_{\lambda,r}(a) = \begin{cases} 1 & \text{for } |a| \leq \lambda \\ \dfrac{\lambda^2}{r(\lambda - |a|)^2 + \lambda^2} & \text{for } |a| > \lambda \end{cases}$$

Anisotropic mean curvature flow

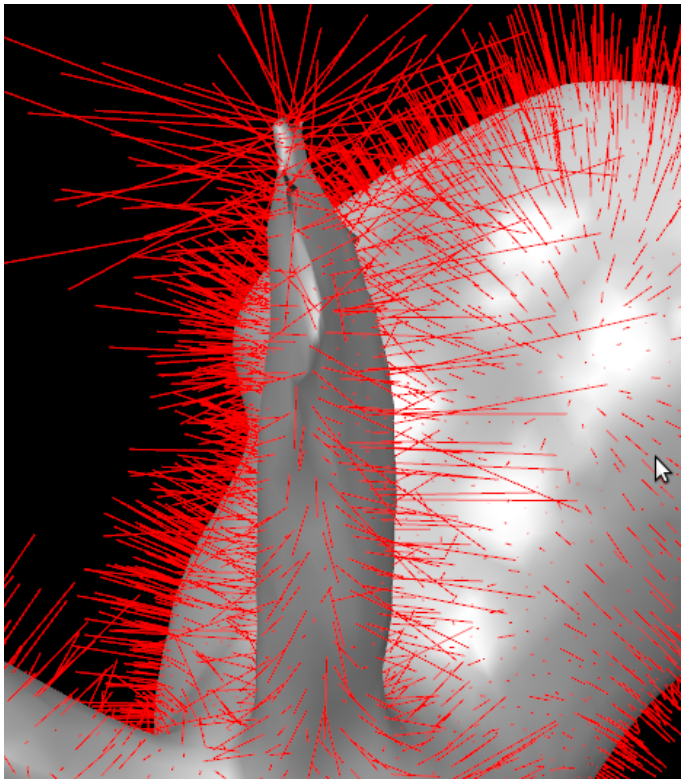
- Explicit iteration step of the anisotropic mean curvature flow

$$p^{j+1} = p^j - \frac{3s}{area(star\ p^j)} \vec{H}_A(p^j)$$

- s controls the speed of a integration step

Drawback of Anisotropic mean curvature

- slow down the smoothing process in regions with high curvature.
- cause deformations of the surface



Prescribed Mean Curvature

- compute mean curvature, smooth this scalar field
- evolve the surface towards a surface having this smoothed mean curvature

$$p^{j+1} = p^j - \frac{3s}{area(star\ p^j)}(\vec{H}_A(p^j) - f(p^j)\vec{V}_A(p^j))$$

- f is a function, that prescribes the anisotropic mean curvature
- $\vec{V}_A$ is an anisotropic volume gradient.

Anisotropic Prescribed Mean Curvature

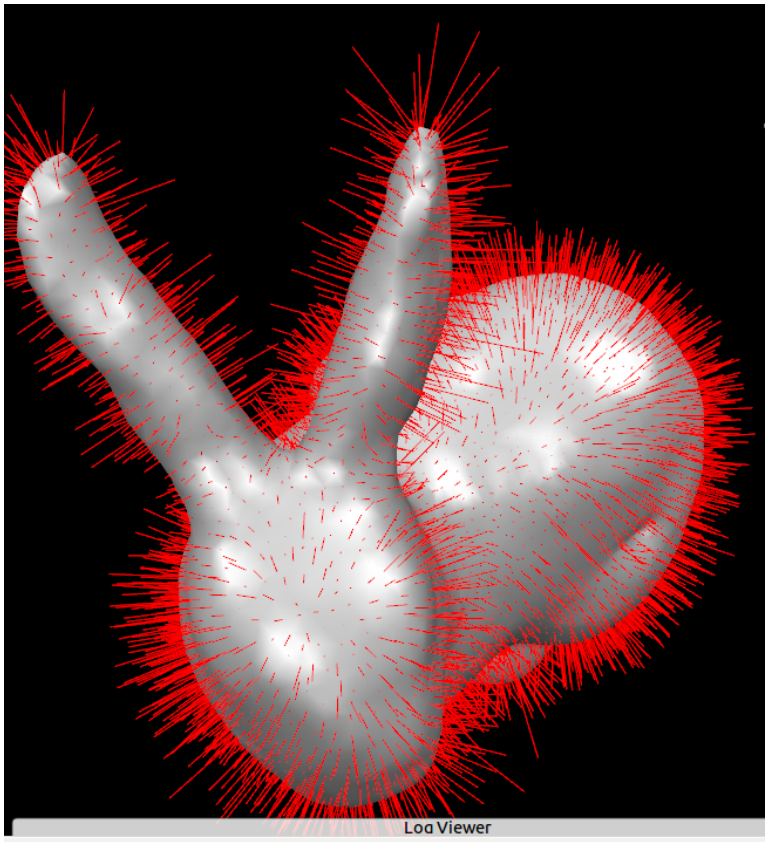


Figure : after 30 iterations: preserve surface features and avoid the deformations

Summary

- Anisotropic mean curvature: reduce smoothing in high curvature regions
- Anisotropic prescribed mean curvature: evolve the surface to the precomputed, smoothed mean curvature

- Future work
  - Implement implicit integration methods