Local Volume Preservation for Skinned Characters

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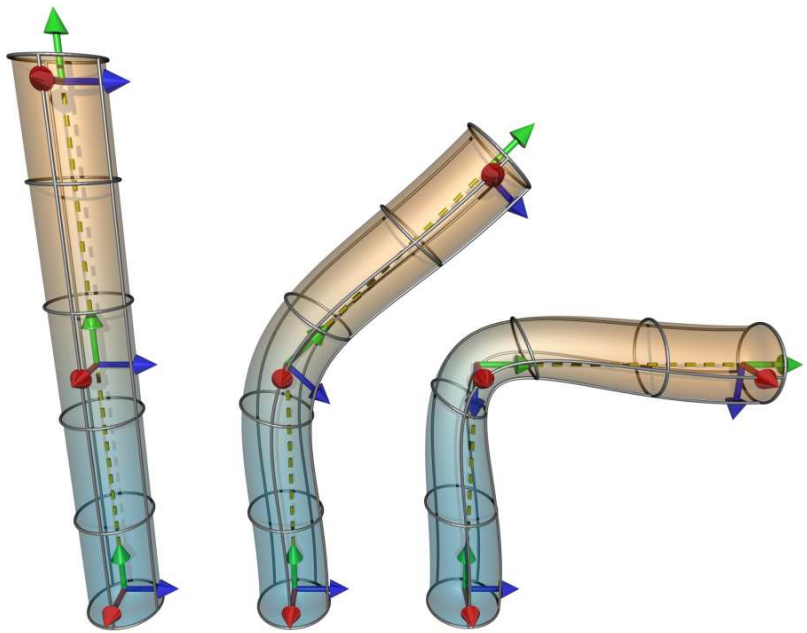
Motivations : Character Animation

- **Fast** and **Intuitive** deformations methods.
- **Realistic behavior** of organic tissues.
- **Fold-Over free**.
- **No additional work** for the artist.

Skinning Method = SSD

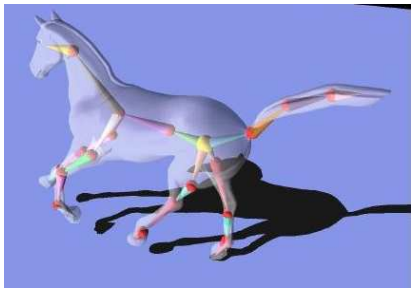
$$\mathbf{x} = \sum_{\text{bones}_k} \omega_k \mathrm{T}_k \mathbf{x}^0$$



- Unrealistic Loss of Volume : **Collapsing Elbow**

Skinning : State of the Art

- Example based techniques
  - Pose Space, [*Lewis et al. 2000*]
  - Matrices of influences, [*Wang et al. 2002*]
  - Automatic skinning parameters building, [*De Aguiar et al. 2008*]



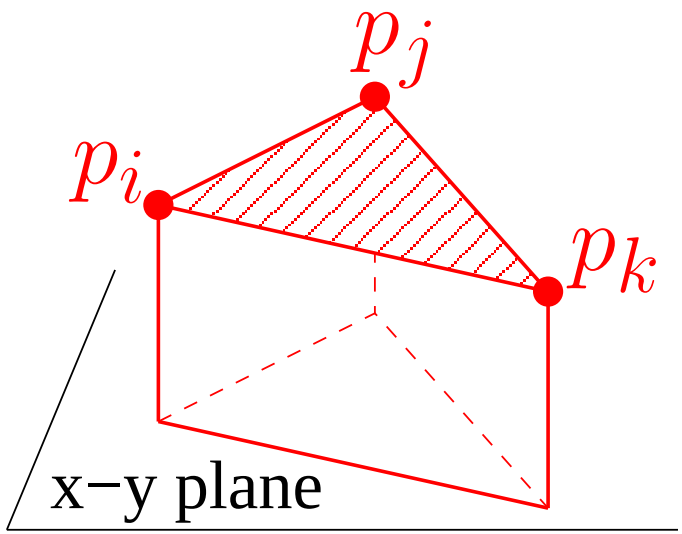
- Skinning Improvement
  - Medial Axis, [*Bloomenthal, 2002*]
  - Dual Quaternions, [*Kavan et al. 2008*]

Our Approach

1. Use classical skinning
2. Post-Correction of the Volume

Volume Computation on a Mesh

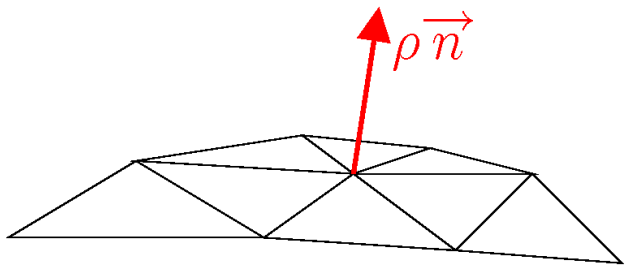
- $V(\mathbf{x}) = \sum_{\text{triangles}} z_{avg}\,\mathcal{A} = \sum_{(i,j,k)} \beta_{ijk} x^i y^j z^k$



Our Volume Correction

- Minimisation to solve :
  Look for a **deformation vector** $\rho\mathbf{n}$

$$\begin{cases} \min & \sum_k {\rho_k}^2 \\ \text{subject to} & V(\mathbf{x}+\rho\mathbf{n}) = V(\mathbf{x}^0) \end{cases}$$



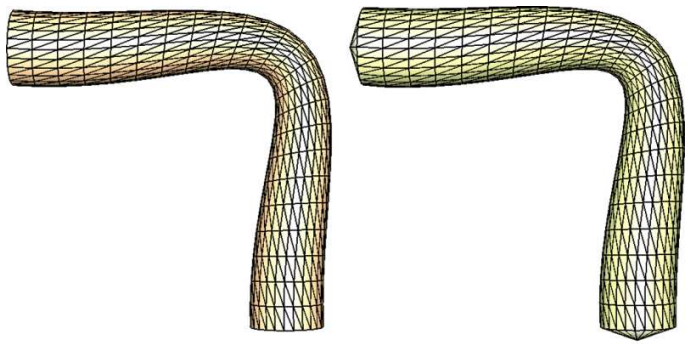
- Efficient Implementation : **Closed form solution**

$$\rho_k = \Delta V \frac{< \mathbf{n}_k, \nabla V(\mathbf{x}_k) >}{\sum_j < \mathbf{n}_j, \nabla V(\mathbf{x}_j) >^2}$$

Assuming $V(\mathbf{x}+\rho\mathbf{n}) \simeq V(\mathbf{x}) + < \rho\mathbf{n}, \nabla V(\mathbf{x}) >$.

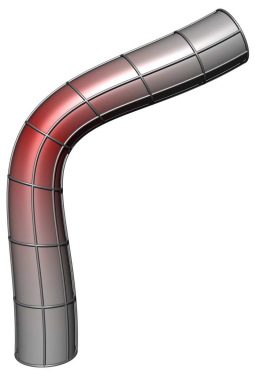
Basic approach

- Uniform correction leads to a global inflation.



  - Introduce a **Correction Map** γ.

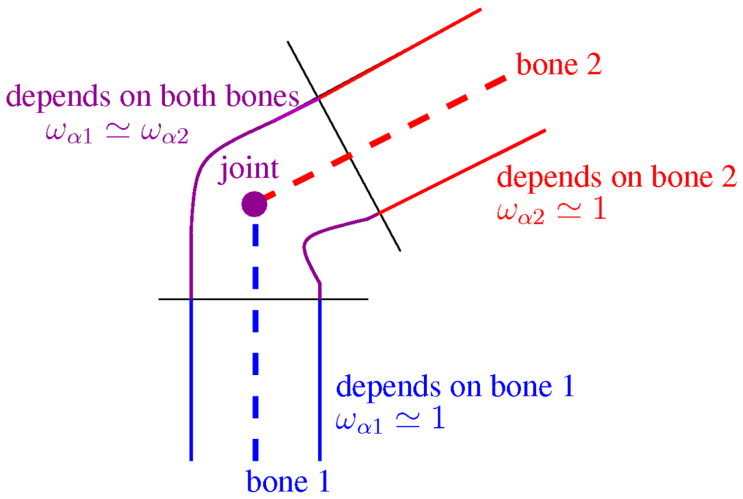
$$\begin{cases} \min & \sum_k \frac{\rho_k^2}{\gamma_k} \\ \text{subject to} & V(\mathbf{x} + \rho\mathbf{n}) = V(\mathbf{x}^0) \end{cases}$$



  - **Closed form** solution is preserved.

Correction Map based on Skinning Weights

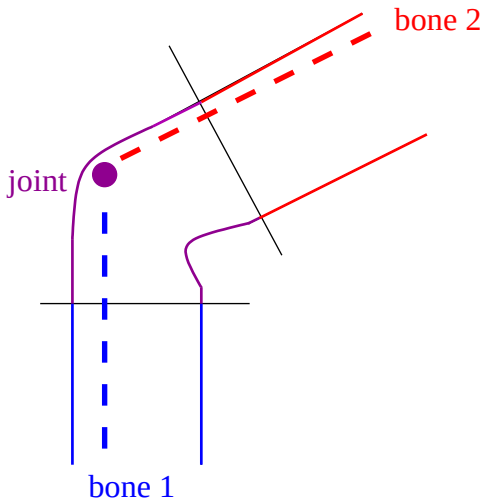
$$\gamma = (1 - \omega \text{max})^{\alpha}$$



- Rubber Effect :

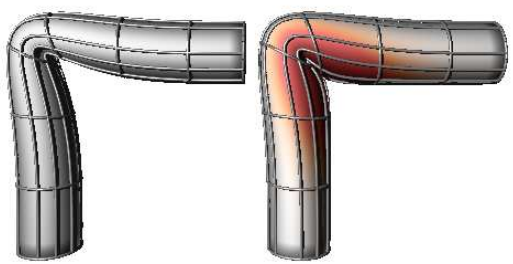
Correction Map with Off-Centered Skeleton

$\gamma = (1 - \omega \text{max})^{\alpha} d_{\text{min}}^{\beta}$
d=distance to bone



- Organic Effect :

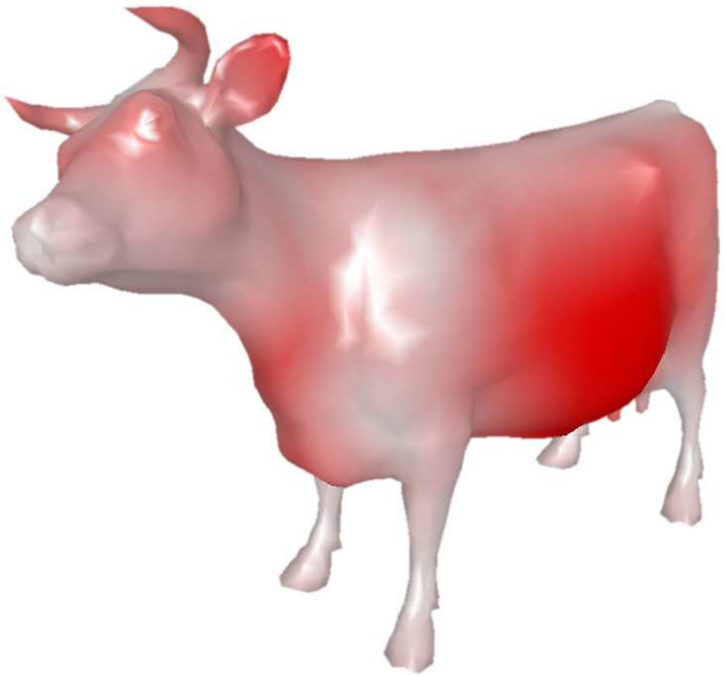
Importance of an Anatomical Skeleton



Dealing with Full Characters

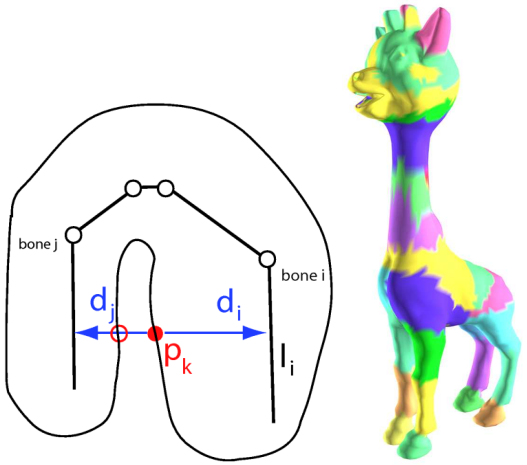
ΔV has to be known locally

Need to localize the Compensation of Volume

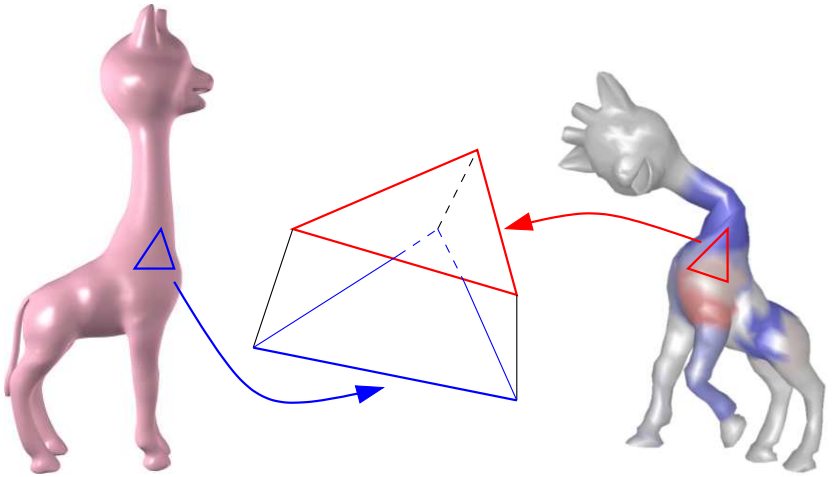


Dealing with Full Characters

- Precomputation Part :
  - Automatic **skinning weights** computation
  - Automatic **Segmentation** (same influencing bone)



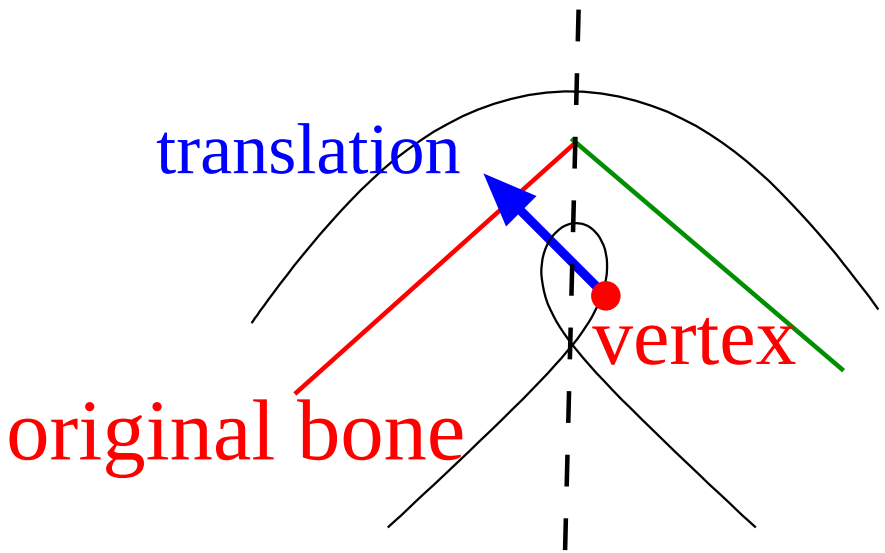
- At each Time Step : Estimation of the **local change** of volume



Avoiding Fold-over

Automatic Skinning weights indicate **inter-penetration**.

- Check whether bone dependence has changed.
  $\Rightarrow$ Translate back toward its original bone.

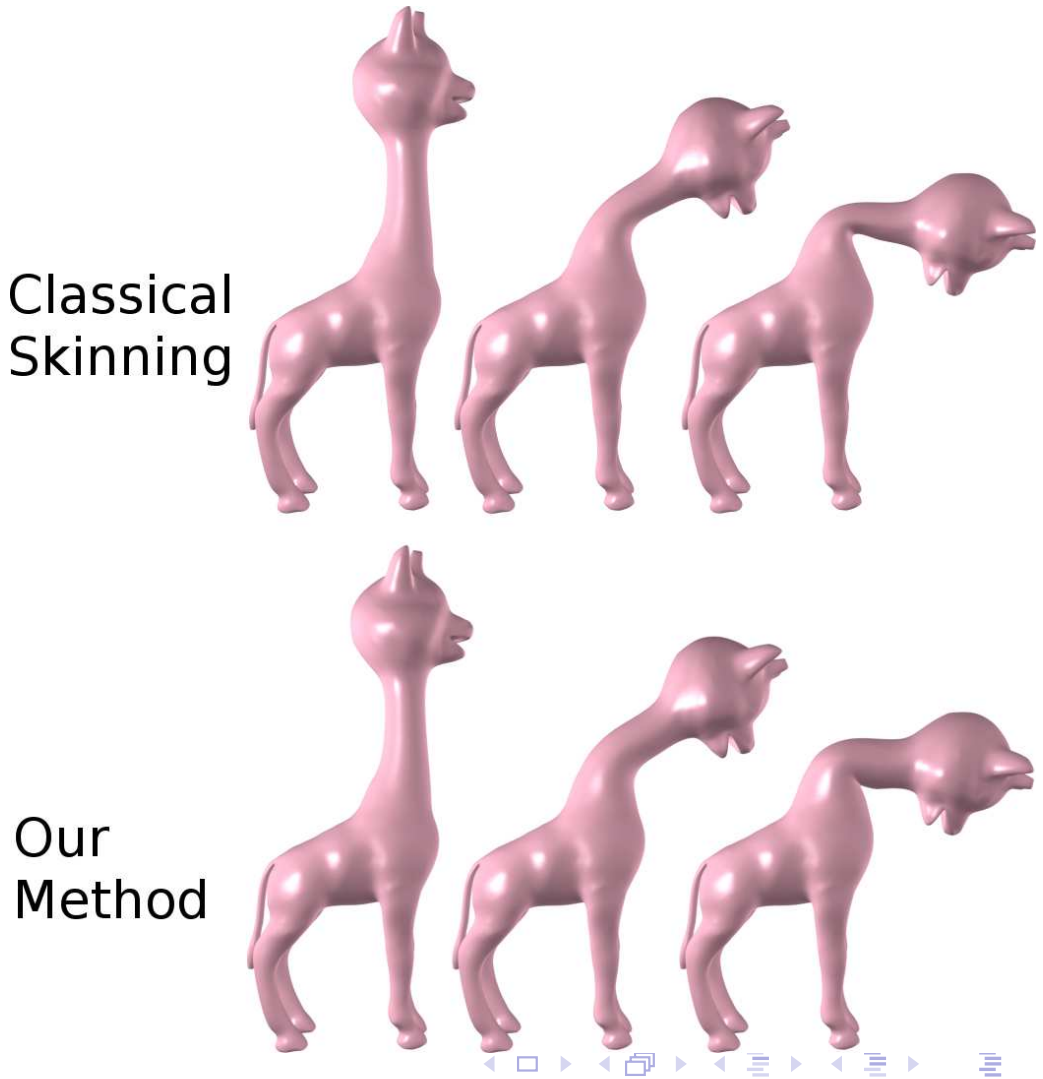


Results (Giraffe)

Parameters

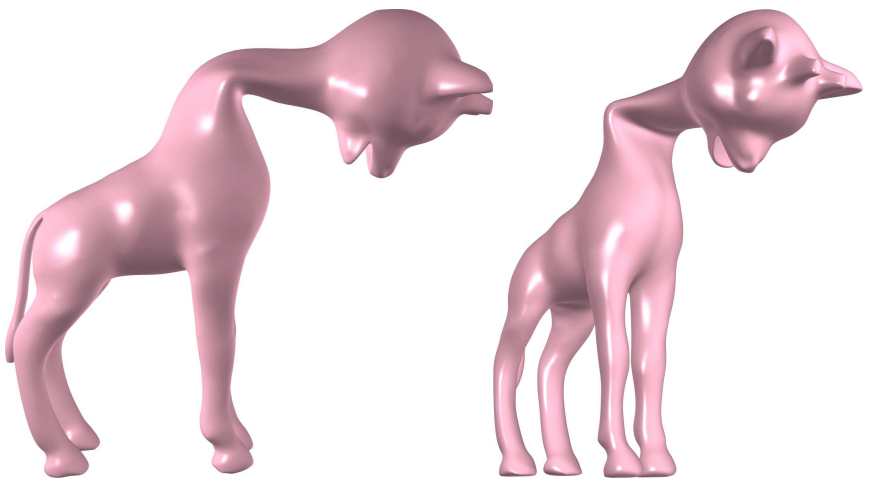
- **Organic** Giraffe
- 1667 vertices

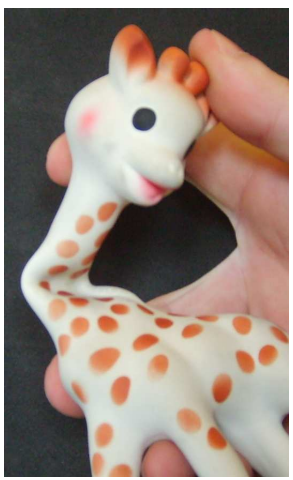
SSD	Our Method
27 fps	19 fps



Results (Giraffe)

- **Rubber** Giraffe
  (γ does not use distance to bone information)



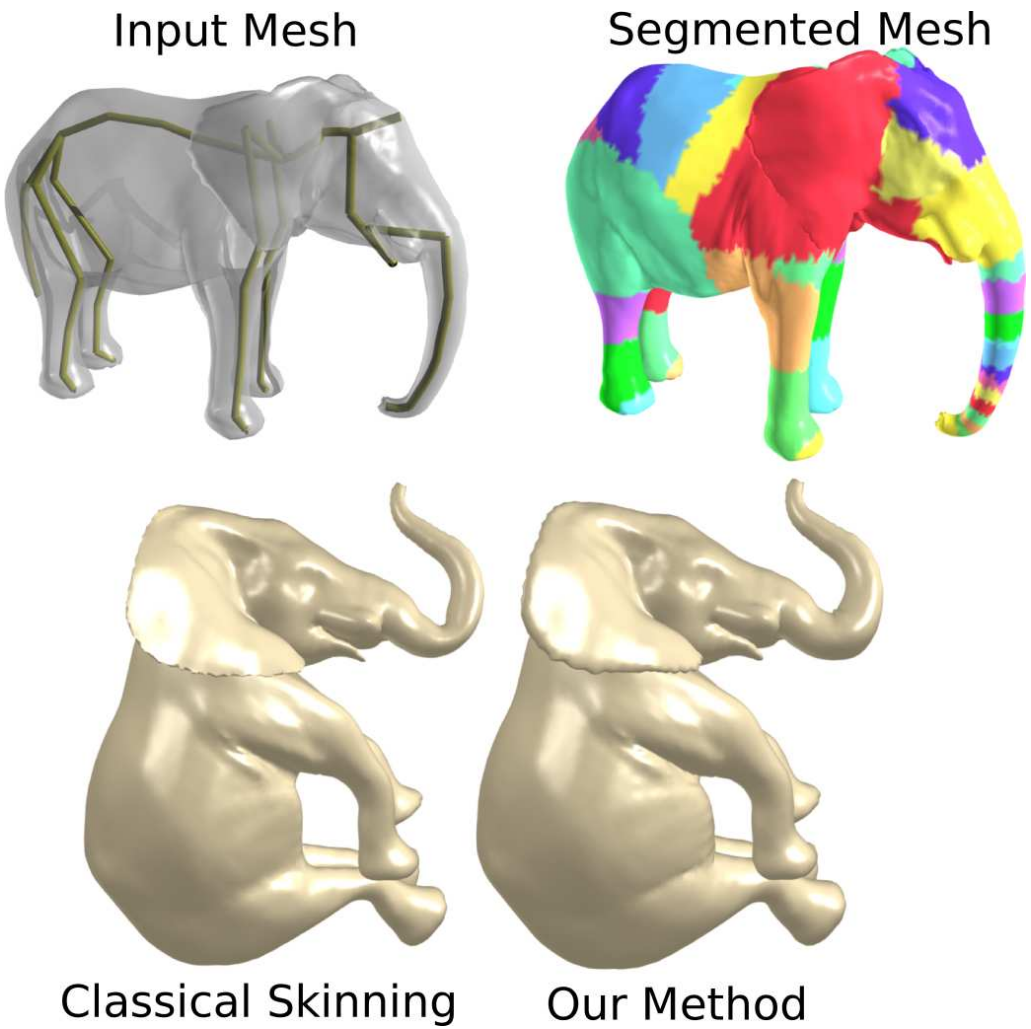


Results (Elephant)

Parameters

- **Organic** Elephant
- 5720 vertices

SSD	Our Method
23 fps	16 fps

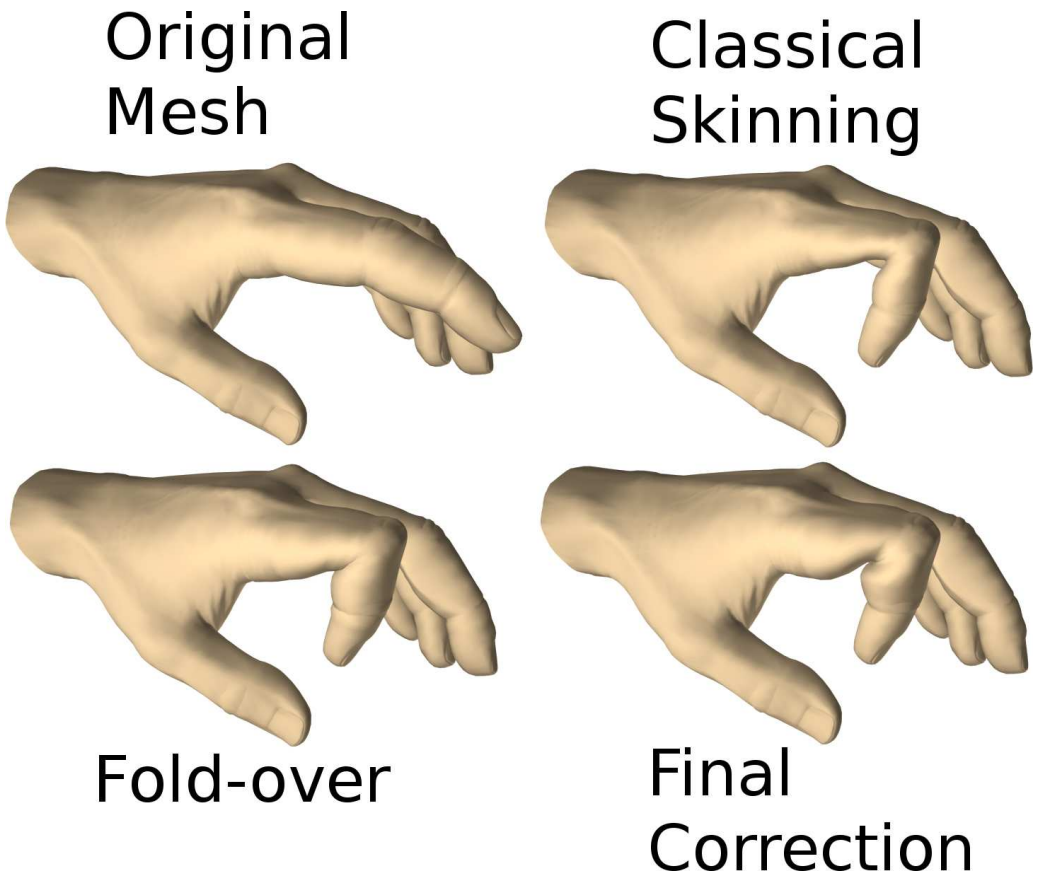


Results (Fold-over for the hand)

Parameters

- 8636 vertices
- Fold over detection over 760 vertices

SSD	Our Method
20 fps	9 fps

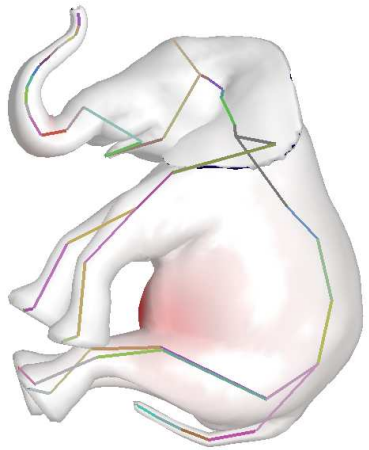


Other results

- Jumping Elephant Video

Limitations and Future Work

- **Manual** addition of some informations for the correction map
  - **merge the influence** of some bones
  - **delete the influence** of other bones



Future Work

- Faster **GPU** implementation.
- Extend to **other skinning methods** (dual quaternion, ...).
- Combine with **dynamic** to add vibrations to flesh parts.

End

Question time

classical skinning

our method