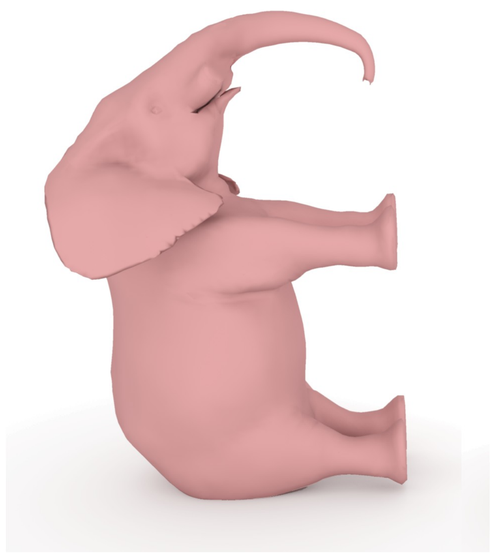
Constant Volume Skinning for Character Animation

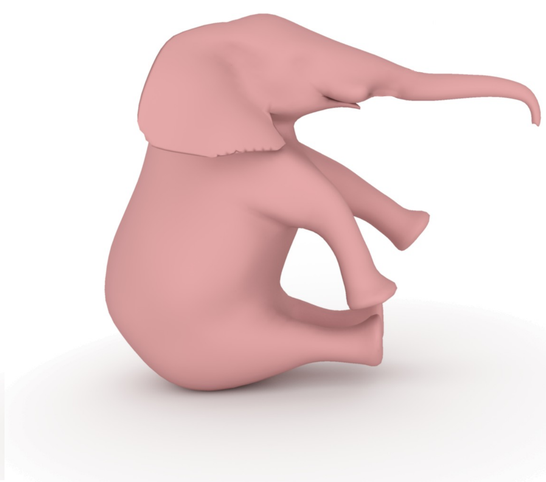
Damien Rohmer, Stefanie Hahmann, Marie-Paule Cani

Aim: Quick and intuitive skin deformation for skeleton animation

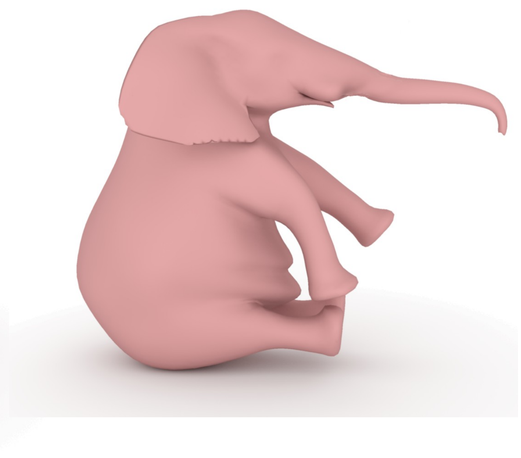
Original shape with skeleton



Original shape



Classical skinning

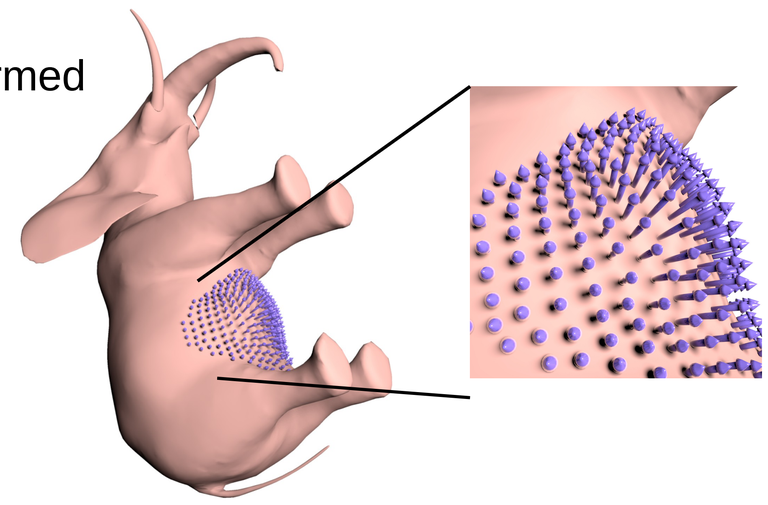


Our method

Two methods to restore the original volume

Normal deformation

Vertices are deformed along the normal direction



Approximate volume compensation in 1 step

Equation to solve

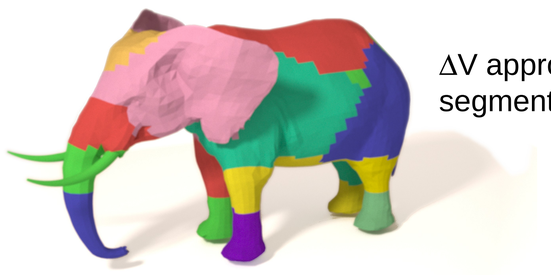
$$\begin{cases} \min \sum_{k=0}^{N-1} \frac{\rho_k^2}{\gamma_k} \\ \text{subject to } V(\mathbf{p}_k + \rho_k \mathbf{n}_k) = V(\overline{\mathbf{p}}_\mathbf{k}) \end{cases}$$

ρ_k^2: Magnitude of the deformation; γ_k: Local weighting; $\mathbf{n}_k$: Surface normal; $\overline{\mathbf{p}}_\mathbf{k}$: Original shape

Closed form solution

$$\rho_k = \Delta V \frac{\gamma_k < \mathbf{n}_k, \nabla V(\mathbf{p}_k) >}{\sum_{j=0}^{N-1} \gamma_j < \mathbf{n}_k, \nabla V(\mathbf{p}_k) >^2}$$

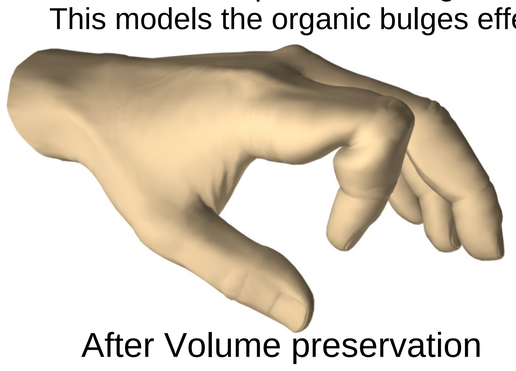
ΔV: Change of volume



ΔV approximated locally on each segment

Distance (bone,vertex) taken into account to compute local weights.
This models the organic bulges effect.

Classical skinning



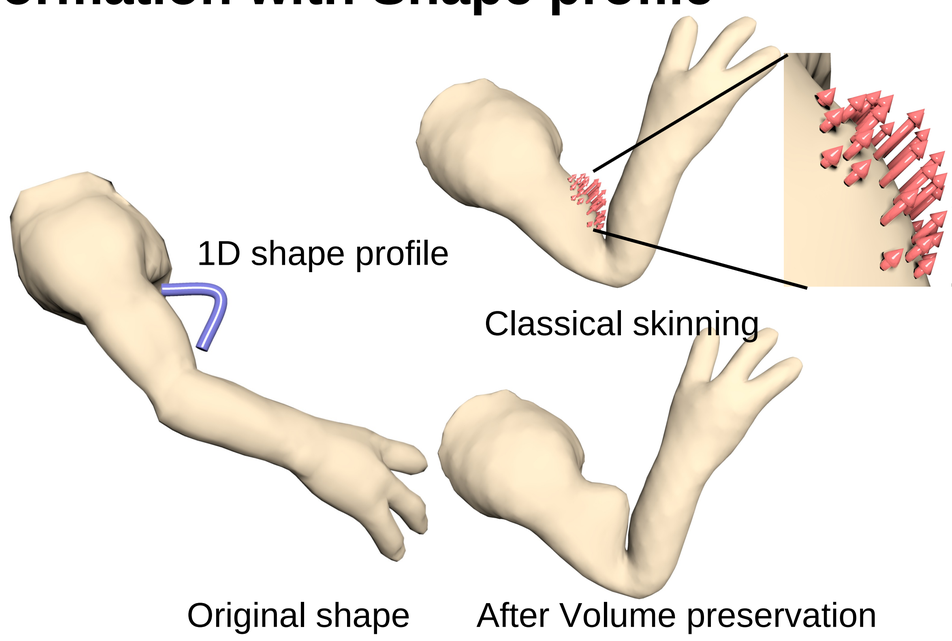
After Volume preservation

⊕ Real time
⊕ No additional parameter
⊖ Approximate volume preservation

Local Volume Preservation for Skinned Characters.
D. Rohmer, S. Hahmann and M.-P. Cani.
Computer Graphics Forum, Vol. 27, 2008.

Deformation with Shape profile

Vertices are deformed in an arbitrary direction according to a 1D profile



Exact volume compensation in 3 steps

$$\begin{cases} \min \sum_{k=0}^{N-1} \frac{\|\mathbf{u}_k\|^2}{\gamma_k} \\ \text{subject to } V(\mathbf{p}_k + \mathbf{u}_k) = V(\overline{\mathbf{p}}_\mathbf{k}) \end{cases}$$

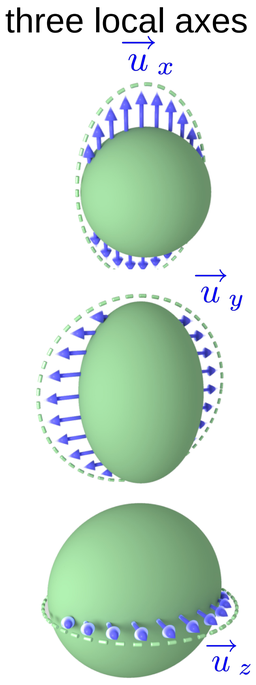
$\|\mathbf{u}_k\|^2$: Vector of deformation

$$\mathbf{u}_k = \gamma_k \Delta V \left(\mu_0 \frac{\frac{\partial V}{\partial x}}{\sum_{j=0}^{N-1} \gamma_j \left(\frac{\partial V}{\partial x}\right)^2}, \mu_1 \frac{\frac{\partial V^\star}{\partial y}}{\sum_{j=0}^{N-1} \gamma_j \left(\frac{\partial V^\star}{\partial y}\right)^2}, \mu_2 \frac{\frac{\partial V^{\star\star}}{\partial z}}{\sum_{j=0}^{N-1} \gamma_j \left(\frac{\partial V^{\star\star}}{\partial z}\right)^2} \right)$$

$\frac{\partial V^\star}{\partial y}$: Derivative of the volume of the surface after the first deformation

$\frac{\partial V^{\star\star}}{\partial z}$: Derivative of the volume of the surface after the two first deformation

Deformation along the three local axes



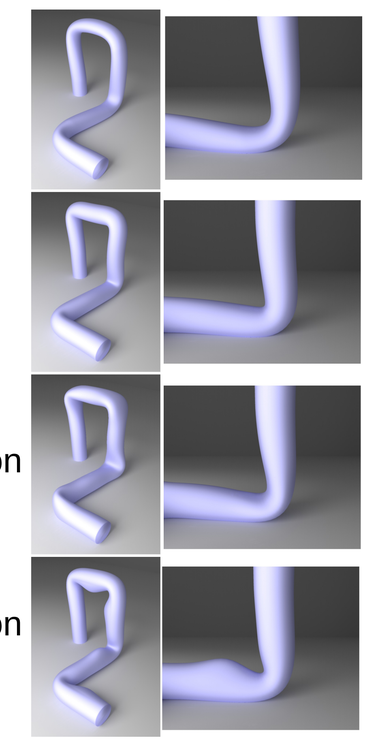
Various correction effects can be parameterized

Classical skinning

Isotropic correction

Anisotropic correction (rubber effect)

Anisotropic correction (muscular effect)



⊕ Exact volume preservation
⊕ Control using 1D profile curves
⊖ Multiple iterations needed

Exact Volume Preserving Skinning with Shape Control.
D. Rohmer, S. Hahmann and M.-P. Cani.
Symposium on Computer Animation 2009.

LABORATOIRE JEAN KUNTZMANN
MATHÉMATIQUES APPLIQUÉES - INFORMATIQUE