252-0538-00L, Spring 2025

Shape Modeling and Geometry Processing

Linear Blend Skinning

INTERACTIVE GEOMETRY LAB

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

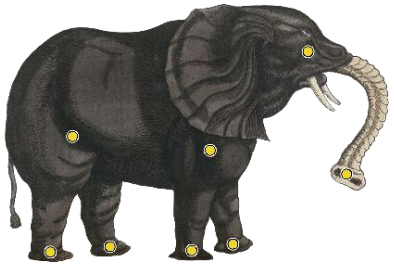
May 14, 2025

Space deformation with various handle types

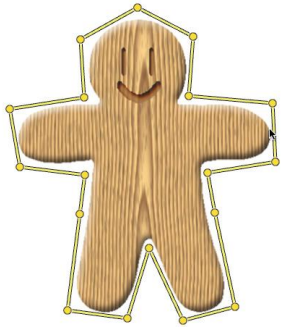
So far we saw: $\mathbf{f} : \mathbb{R}^3 \rightarrow \mathbb{R}^3; \quad \mathbf{x}' = \mathbf{f}(\mathbf{x}) = \sum_j w_j(\mathbf{x})\, \mathbf{p}'_j$

Where $\mathbf{p}_j$ are *positions* of control points of:

regions



points



cages

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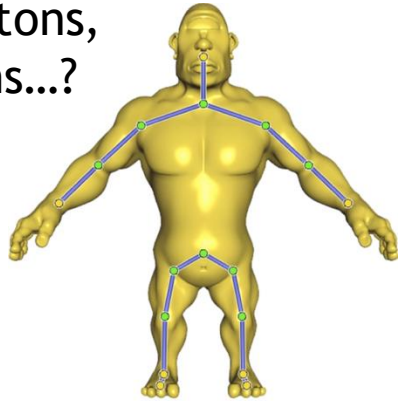
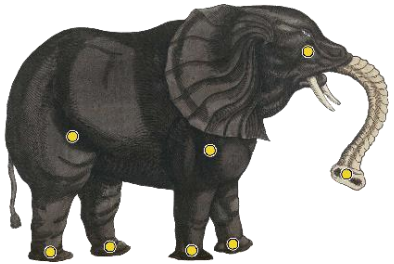
How to generalize to include skeletons, bone rotations…?



skeletons

regions



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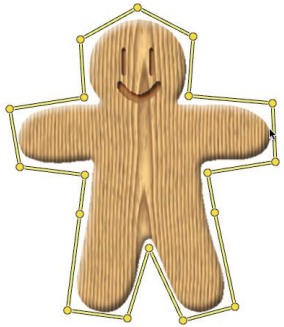
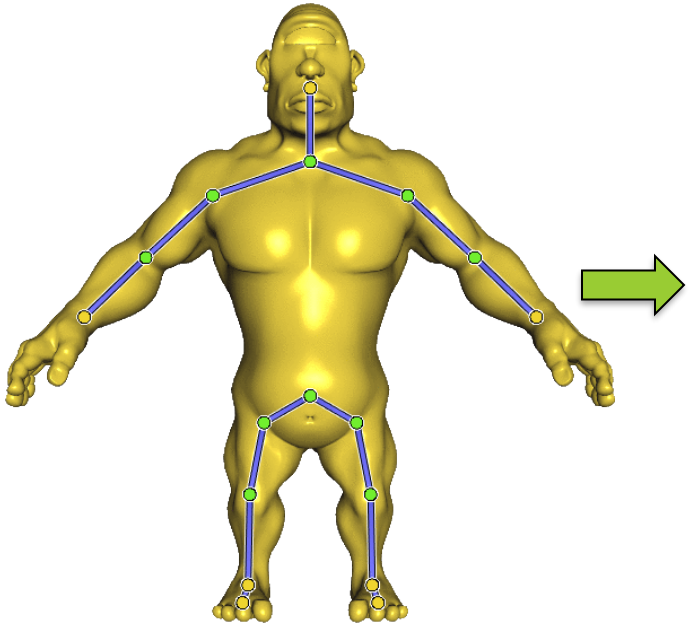


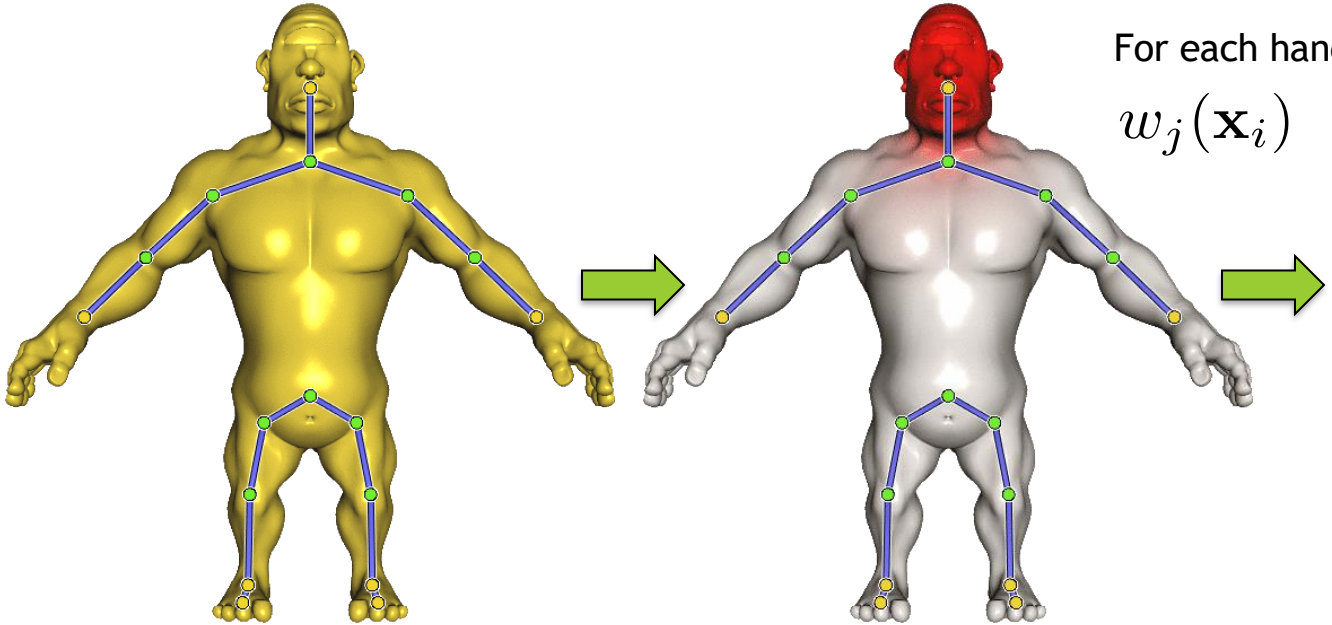
cages

Linear Blend Skinning



place handles in shape

Linear Blend Skinning



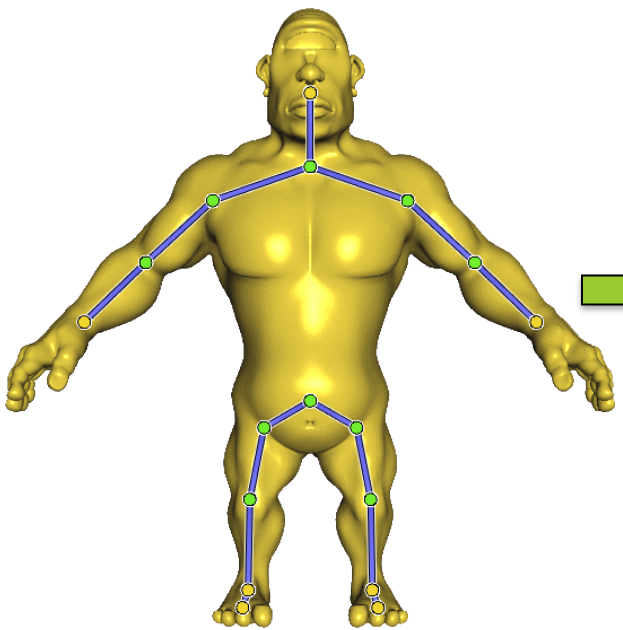
For each handle j

$$w_j(\mathbf{x}_i)$$

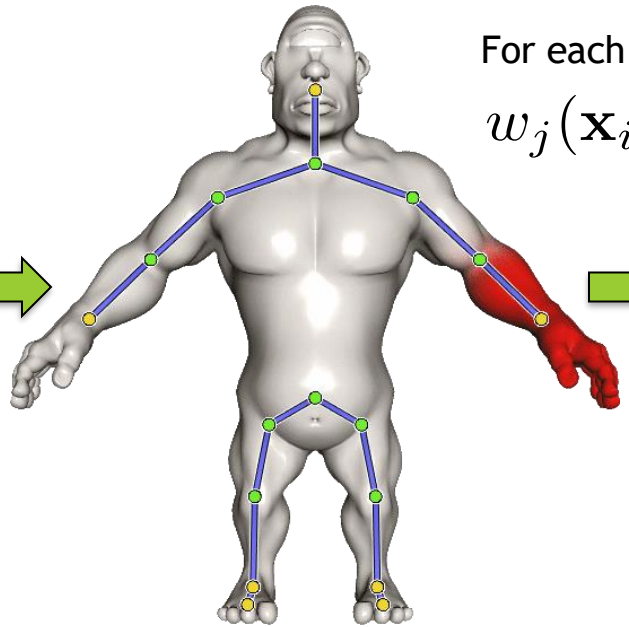
place handles in shape

paint weights

Linear Blend Skinning



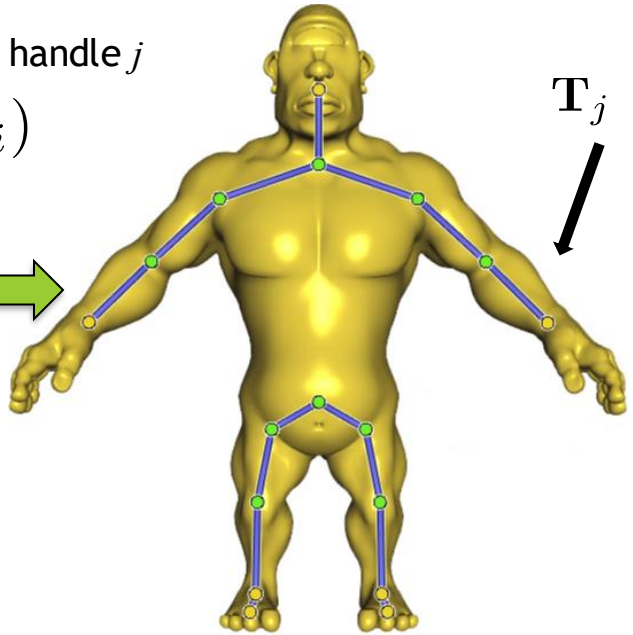
place handles in shape



paint weights

For each handle j

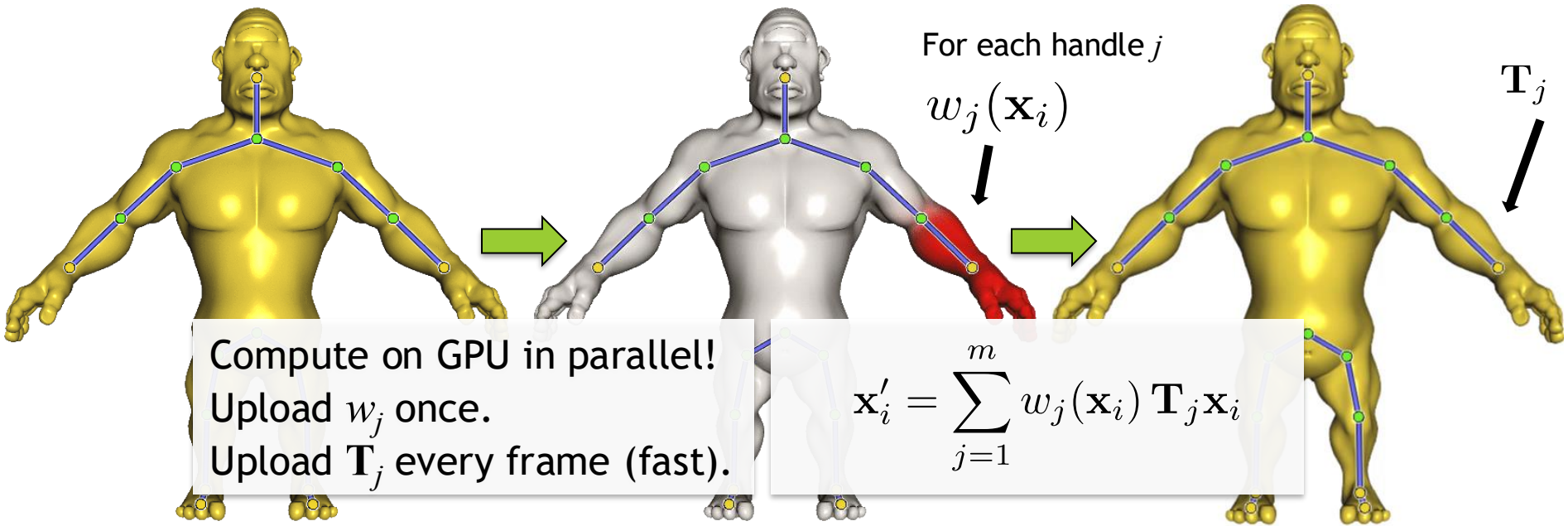
$$w_j(\mathbf{x}_i)$$



$$\mathbf{T}_j$$

deform handles

Realtime performance, parallelizable



Compute on GPU in parallel!
Upload w_j once.
Upload $\mathbf{T}_j$ every frame (fast).

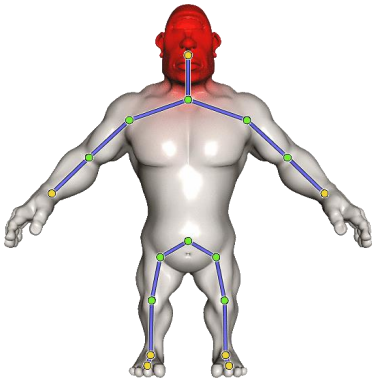
$$\mathbf{x}_i' = \sum_{j=1}^{m} w_j(\mathbf{x}_i)\,\mathbf{T}_j\mathbf{x}_i$$

place handles in shape | paint weights | deform handles

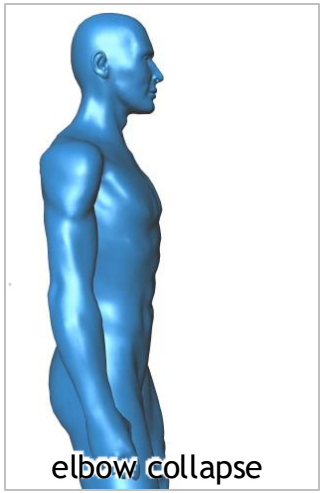
LBS alone is not good enough

- Manual weight painting
  - Unintuitive and tedious

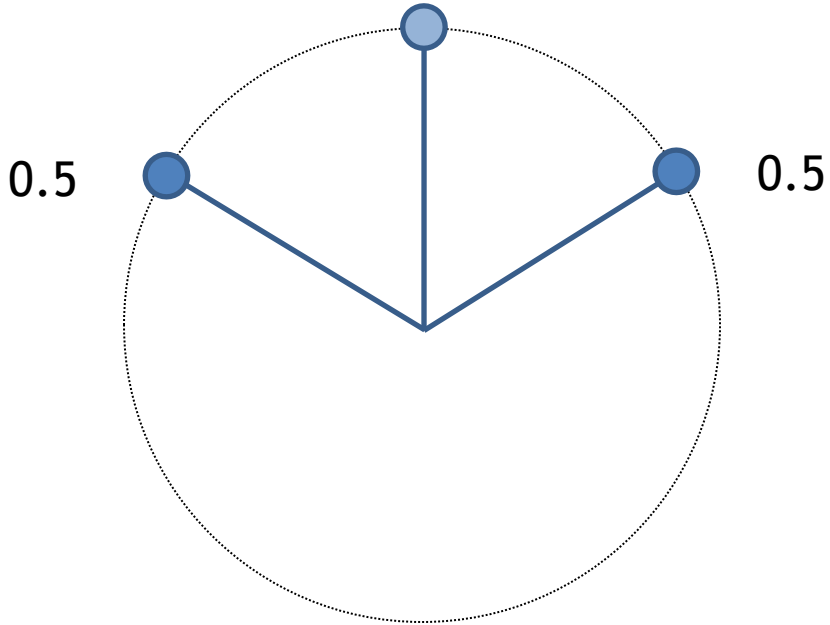
$$\mathbf{x}_i' = \sum_{j=1}^{m} w_j(\mathbf{x}_i)\,\mathbf{T}_j\mathbf{x}_i$$



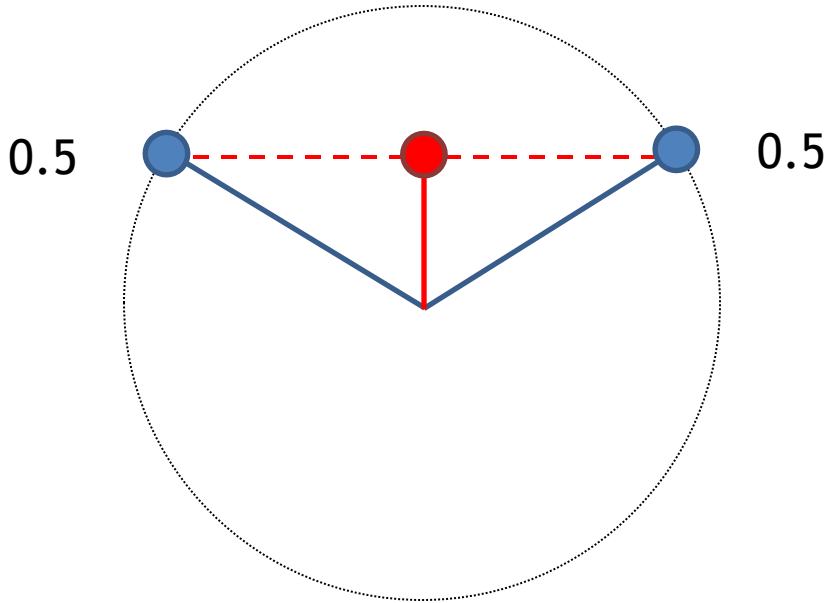
- Artifacts due to linear nature
  - “Elbow collapse”
  - “Candy wrapper”



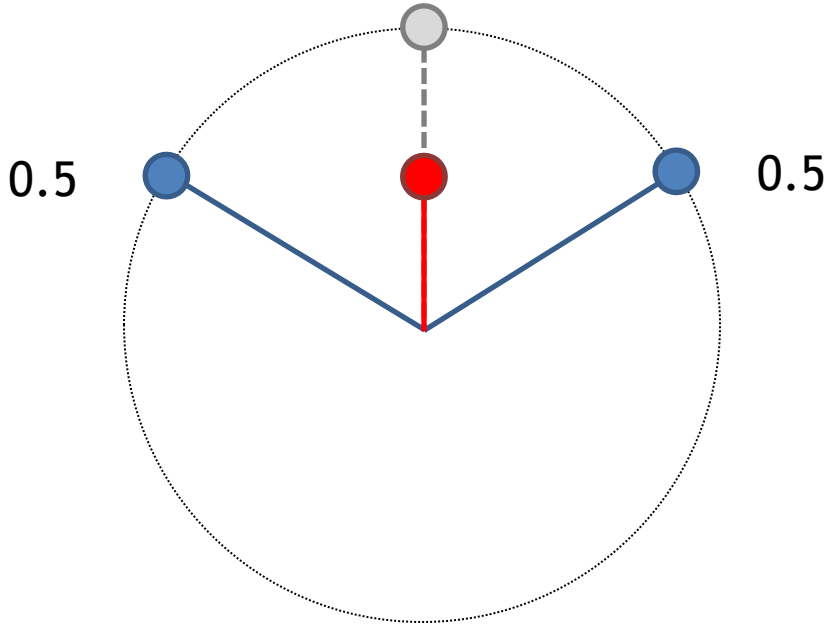
Correct rotation interpolation



Linear interpolation



Linearization of rotations leads to artifacts



LBS alone is not good enough

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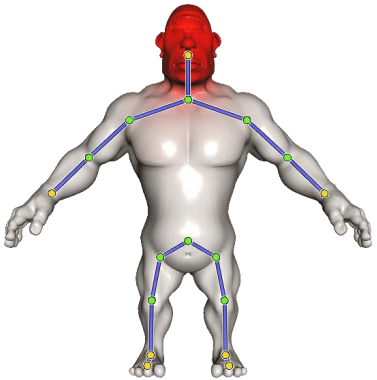
  - Unintuitive and tedious

Algorithm to compute the weights

$$\mathbf{x}_i' = \sum_{j=1}^{m} w_j(\mathbf{x}_i)\,\mathbf{T}_j\mathbf{x}_i$$



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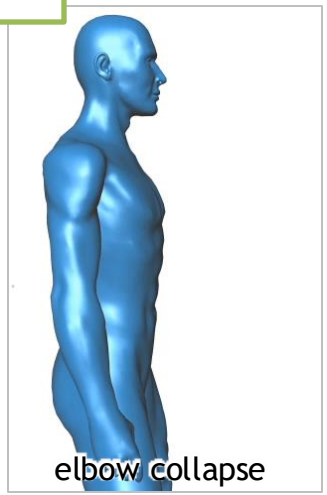
Plug into ARAP as a subspace



Further reading

- Bounded Biharmonic Weights
  https://igl.ethz.ch/projects/bbw/

- Fast Automatic Skinning Transformations
  https://igl.ethz.ch/projects/fast/

- Elasticity-Inspired Deformers for Character Articulation
  https://igl.ethz.ch/projects/eid/

Next week: Guest Lecture!

May 21, 10:15:

Prof. Barbara Solenthaler

Multimodal 3D head modeling and simulation for medical applications

Thank You!

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