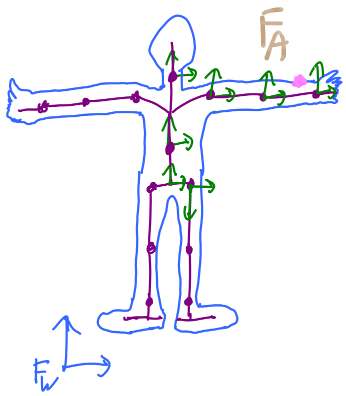
Character Skinning

- also known as "enveloping"
- brief history of character animation (in games)
  - characters as sequences of images: "sprites"
  - characters as sequences of 3D meshes
    - hand crafted poses of a mesh
  - skeleton-based animation
    - i.e., attach a mesh to underlying skeleton
- Summary of techniques
  1. Linear blend skinning (and extensions)
  2. Spatial deformations - FFDs, cages, wires
  3. Anatomically-driven models (muscle)
  4. Data-driven methods.

① Linear blend skinning



$$P_W = M_{A\to W} P_A$$

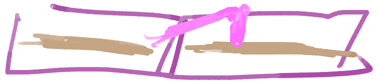
$$P_A = M_{A\to W}^{-1} P_W$$ computing "bind" coordinates

during animation, link A will move

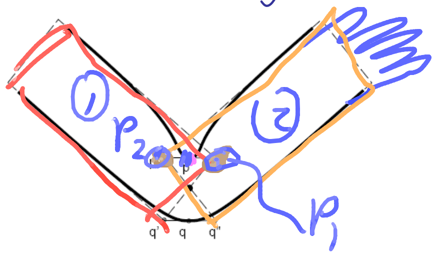
$$P_W' = M_A' P_A$$
$$= M_A' M_A^{-1} P_W$$

Simplest skinning
- each vertex is rigidly attached to "closest" bone

Better skinning
- allow vertices to be shared or influenced by multiple bones



Linear Blend Skinning (Skeletal Subspace Deformation: SSD)



$$p_w' = \sum_i \alpha_i \, p_{w_i}'$$

links

eg $p = \underline{0.5}\, p_1 + \underline{0.5}\, p_2$

$$p_w' = \sum_i \alpha_i \, M_i' \, M_i^{-1} \, p_w$$

done in vertex shader

How to assign the weights?

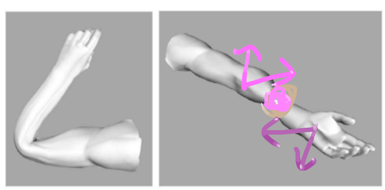
(a) artist "paints" the weights onto the model

(b) automatic

eg: $w_i = \frac{1}{d_i^e}$

$\hat{w}_i = \frac{w_i}{\sum w_i}$ normalization

Linear Blend Problems



$$p_w' = \sum_i w_i \underbrace{M_i' \, M_i^{-1}}_{\text{linear blend of transformation matrices}} p_w$$

$$0.5 \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} + 0.5 \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$$

Fixes:

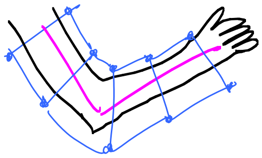
(a) add virtual "halfway" bones
→ manually or automatically

(b) do proper angular blending
→ dual quaternion blend skinning

(c) use per-matrix-element blend weights
(automatically assigned via an algorithm)
$w_i \in \mathbb{R}^9$

② Spatial Deformation Techniques:

FFDs, cages, wires



skeleton

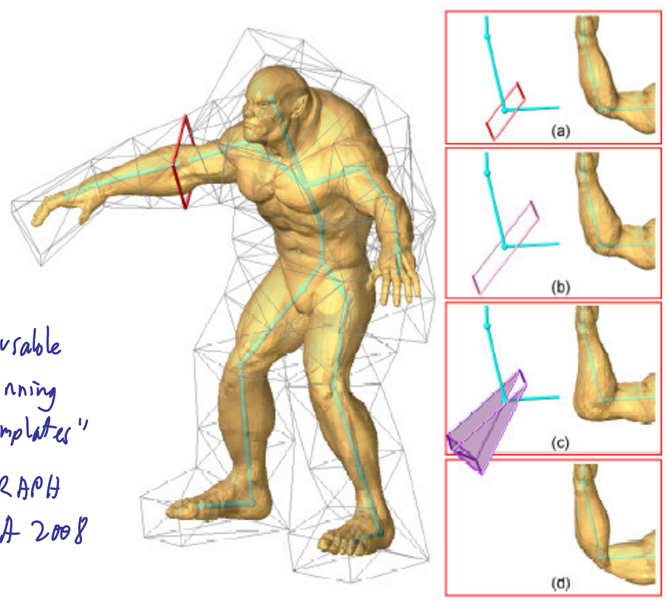
(a) ↓ deforms

FFD/cages/"wires"

(b) ↓ deforms

mesh vertices

- more compute intensive
- improvement over linear blend skinning



"Reusable Skinning Templates"

SIGGRAPH ASIA 2008

③ Anatomically-based and Physically-based Models

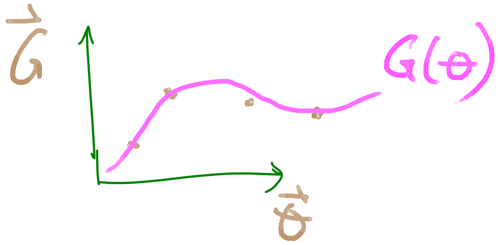
- "simulate" bones, muscles, skin
  - → geometry or physics
- high quality results
- time consuming to setup

④ Data Driven Models

- assume the existence of example poses created by artists, an anatomical model, or data from scanned shapes

$$\{(\underbrace{\vec{G}_i}_{\text{geometry}}, \underbrace{\vec{\theta}_i}_{\text{joint angles}})\}$$

- treat as a regression or scattered-data interpolation problem



SSD = Skeleton subspace deformation
linear blend

$$G'_w(\theta) = SSD(G_w) + \delta(\theta)$$

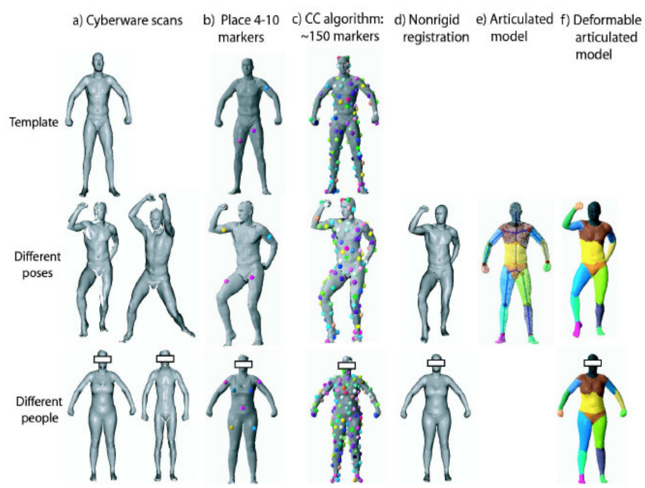
or

$$G'_w(\theta) = SSD(G_w + \delta(\theta))$$

"Pose Space Deformation" SIGGRAPH 2003

"Eigenskin"

$G'(\theta, B)$



"SCAPE" SIGGRAPH 2005

Face Transfer with Multilinear Models

SIGGRAPH 2005.

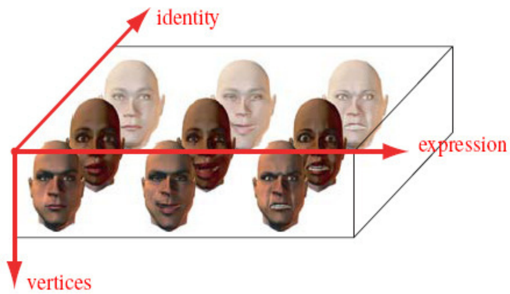
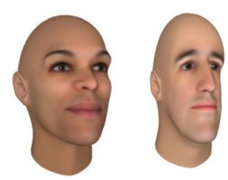
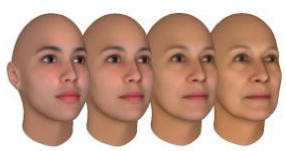


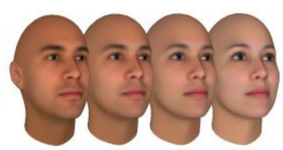
Figure 3: Data tensor for a bilinear model that varies with identity and expression; the first mode contains vertices, while the second and third modes correspond to expression and identity respectively. The data is arranged so that each slice along the second mode contains the same expression (in different identities) and each slice along the third mode contains the same identity (in different expressions). In our trilinear experiments we have added a fourth mode, where scans in each slice share the same viseme.

FaceGen





Age Morphing



Gender Morphing

Race Morphing