Skeleton and Skin

What is skinning?

- Skinning is the process of creating association between the character's skeleton (articulated rigid bodies) and its skin (meshes).

Deformation Algorithms

- Should handle the general problem of skeleton influenced deformation rather than treating each area of anatomy as a special case
- Should allow direct manipulation of the desired deformations
- Common practice: shape interpolation, skeleton subspace deformation (SSD)
- Advanced methods: pose space deformation (PSD), data-driven method, dual quaternion, etc

- Shape interpolation
- Skeletal subspace deformation (skinning)
- Pose space deformation
- Data-driven deformation
- Dual quaternion

Shape Interpolation

- Surface control vertices are a linear combination of the corresponding vertices on key shapes:

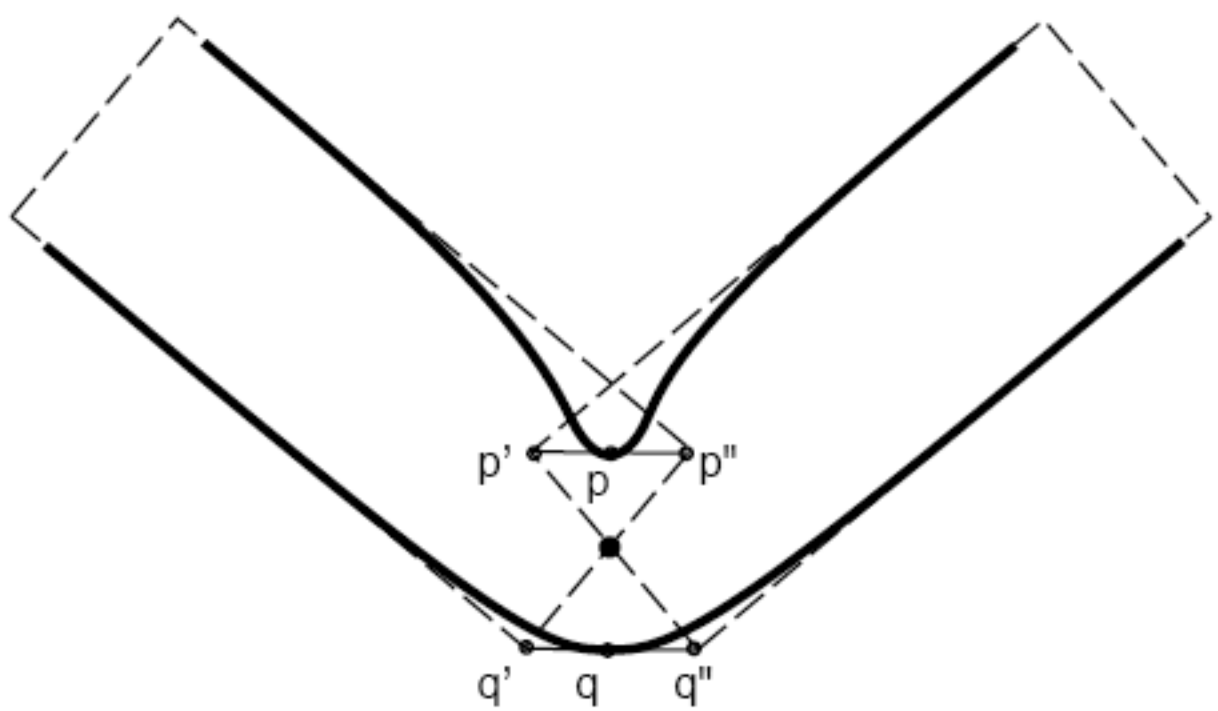
$$S_k : \sum_{k=0} w_k S_k$$

- Shapes are independent of the skeletal motion
- Interpolated shapes might be distorted

SSD (Skinning)

- A vertex on the deforming surface of an articulated object lies in the subspace defined by the rigid transformations of that point

$$\bar{\mathbf{p}} = \sum w_i C_i(\mathbf{p})\mathbf{p}$$



Skin Collapsing

- The vertex position in the mesh deformed by linear blend skinning (SSD) is computed as:

$$\bar{\mathbf{p}} = \sum_{i=1}^{n} w_i C_i(\mathbf{p})\mathbf{p} = \left(\sum_{i=1}^{n} w_i C_i(\mathbf{p}) \right) \mathbf{p}$$

Dual Quaternion Skinning

- Dual quaternion skinning solves the problem of linear skinning methods with minimal additional cost.
- No skin collapsing effects exhibited by linear skinning will manifest themselves.
- Maya uses dual quaternion skinning now.

Maya Demo

- Rigid bind
- Linear skinning with diff max bone numbers
- Dual quaternion
- Interactive smooth bind
- Paint weights

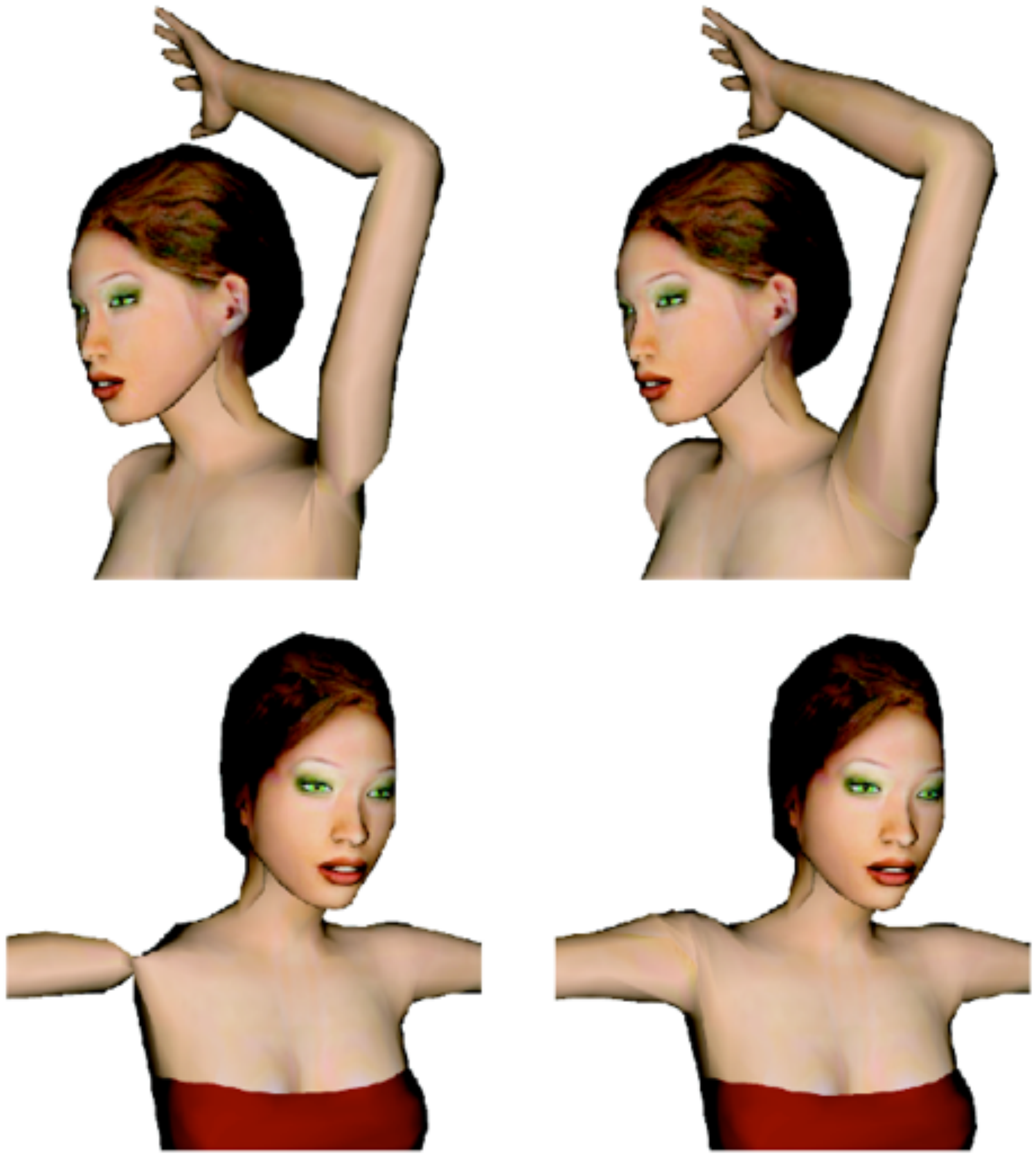
Dual Quaternion

- Define dual numbers
- Define dual quaternion
- Define unit dual quaternion
- Rotation using dual quaternion
- Translation using dual quaternion
- Rigid transformation

Blend Dual Quaternions

$$DLB(\mathbf{w};\hat{\mathbf{q}}_1,\ldots,\hat{\mathbf{q}}_n) = \frac{w_1\hat{\mathbf{q}}_1 + \ldots + w_n\hat{\mathbf{q}}_n}{\|w_1\hat{\mathbf{q}}_1 + \ldots + w_n\hat{\mathbf{q}}_n\|}$$

DLB always returns a rigid transformation, because DLB computes a unit dual quaternion



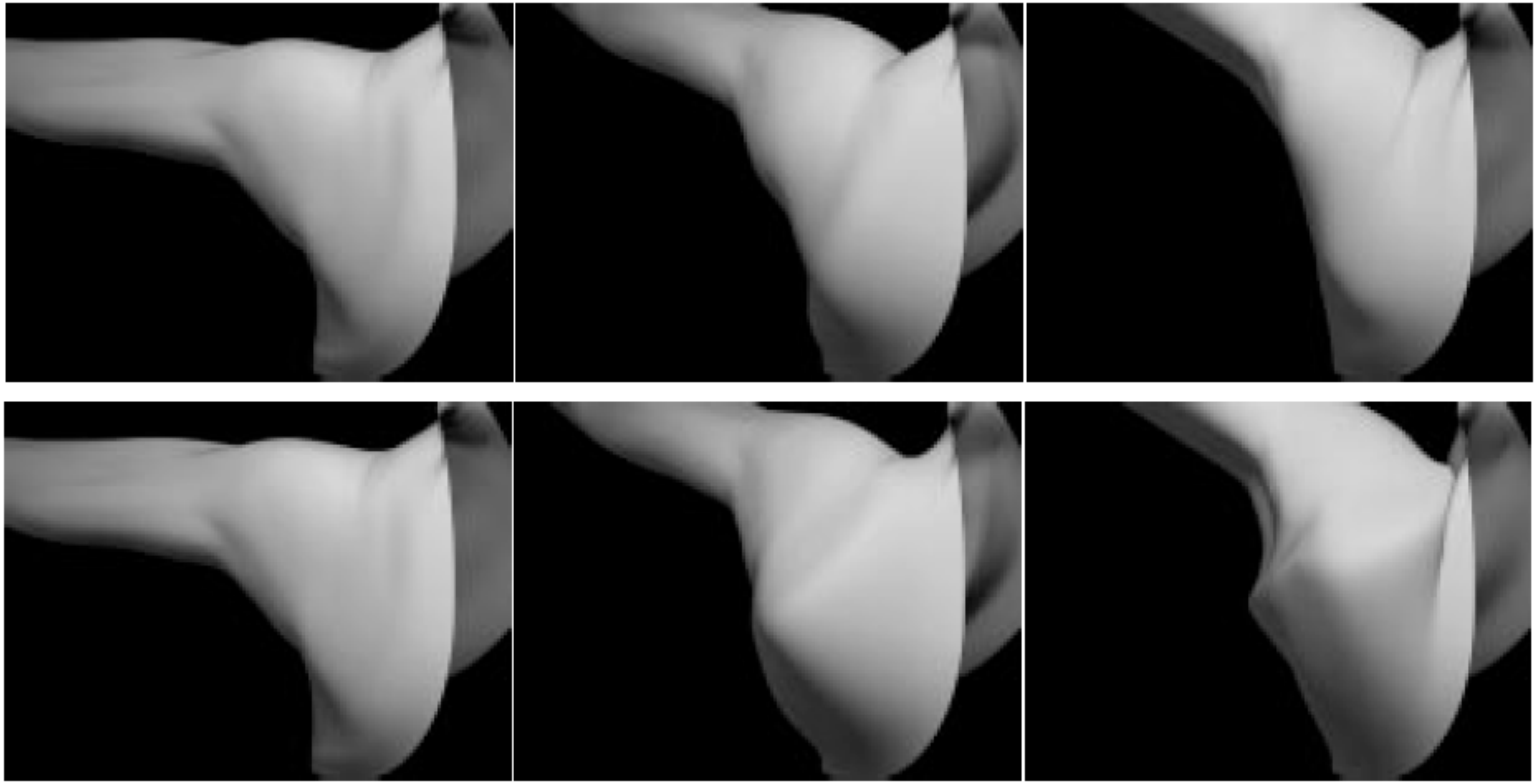
Pose Space Deformation

- The artist sculpts a deformation for a given pose and assigns a falloff function for interpolation
- Define deformation function at sculpted poses

rigid movement with skeleton $\rightarrow$ $\mathbf{p} + \delta(\mathbf{q})$ $\leftarrow$ deviation for this pose

- Interpolate deformation for each vertex based on the current skeleton pose
- Adjust interpolated deformation if needed

PSD vs SSD



Data-driven Deformation

- Use a mocap system and 350 markers to capture body deformation
- The skin motion can be computed by segmenting the markers into rigid motion and a residual deformation

Capturing and Animating Skin Deformation

Robotics Institute,
Carnegie Mellon University

Range Scans

- Example data consists of range scans of a human body in a variety of poses
- Construct a mutually consistent parameterization of all the scans using a posable subdivision surface template
- The detail deformations are represented as displacements from this surface