Motion Synthesis By Example

A Tutorial in 3 and 3/2 parts

Michael Gleicher

Dept of Computer Sciences
University of Wisconsin - Madison

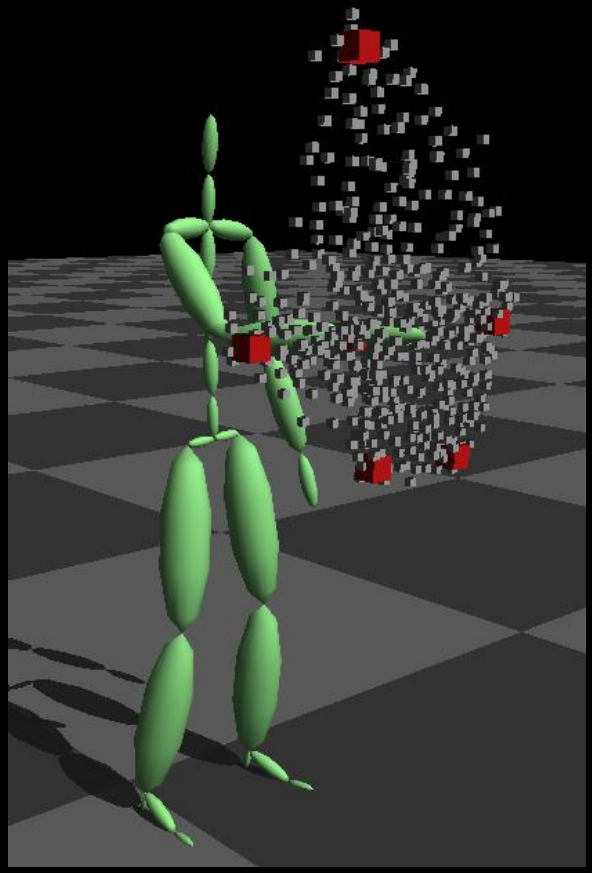
Motion Synthesis By Example

Blending

Michael Gleicher

Dept of Computer Sciences
University of Wisconsin - Madison

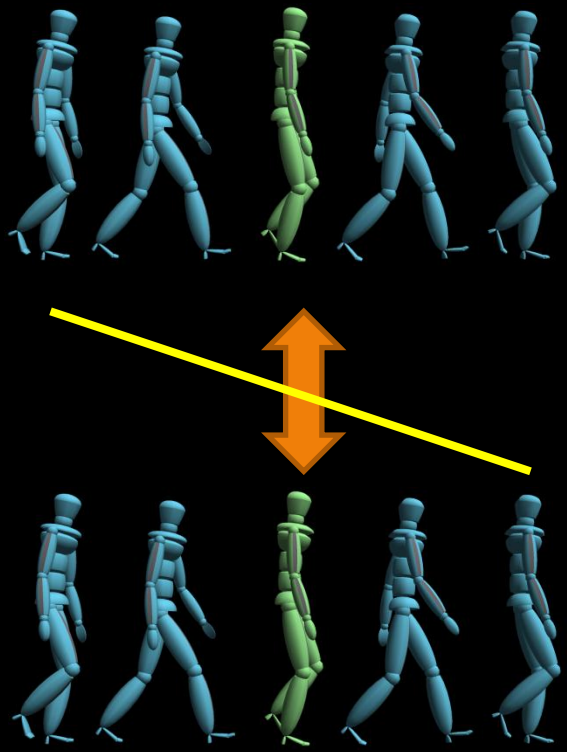
Motions Between examples

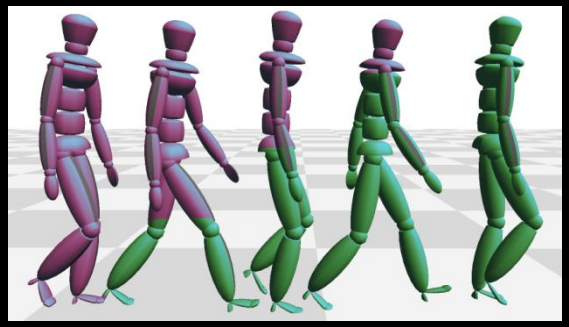


Blending is useful for:

- Transitions

- Blend to avoid bad artifacts

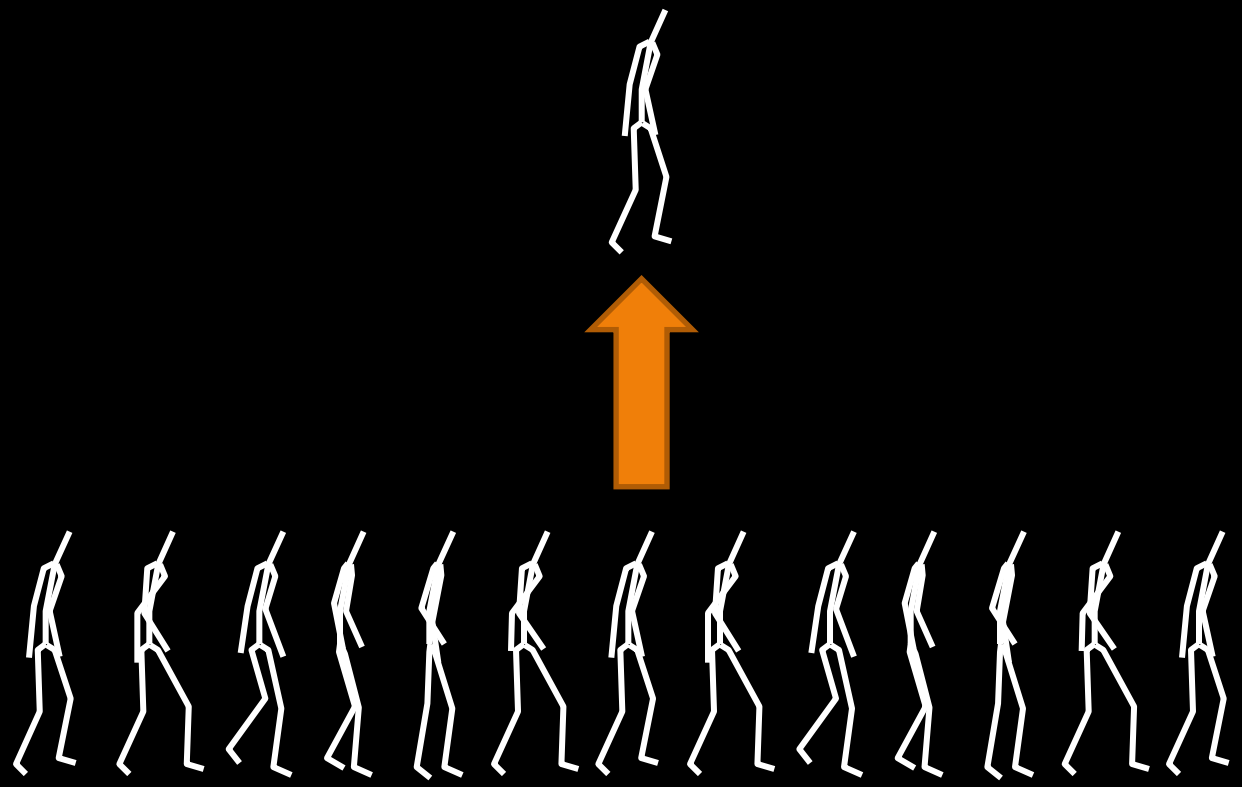


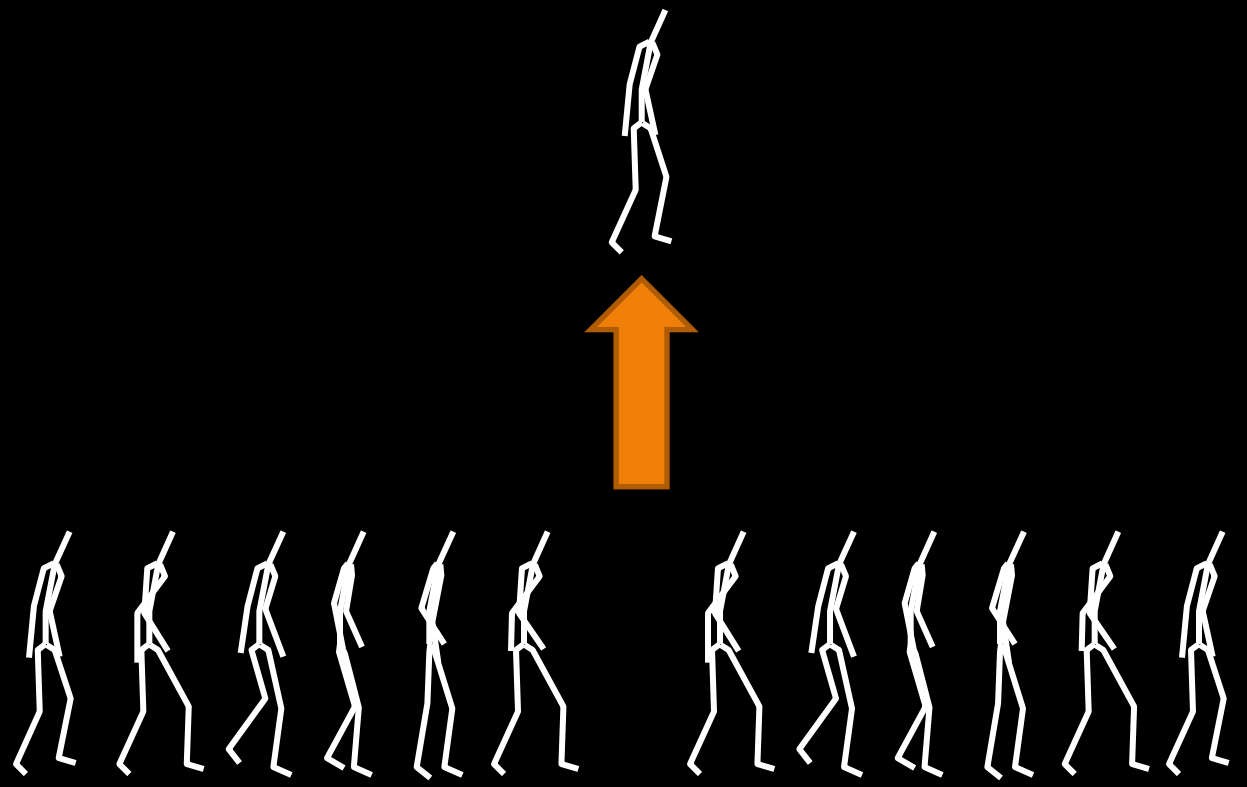


$$q(t) = \alpha q_1 + (1 - \alpha) q_2$$

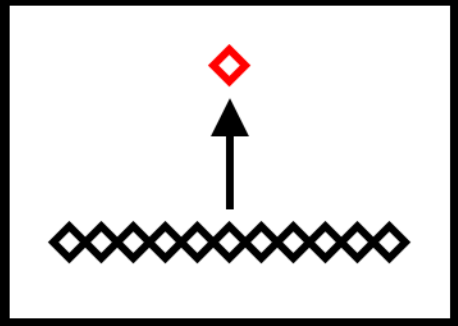
Blending is useful for:

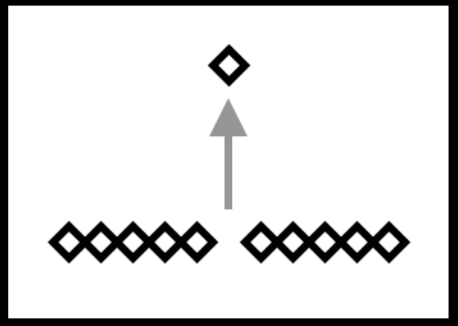
Adjustments / Edits

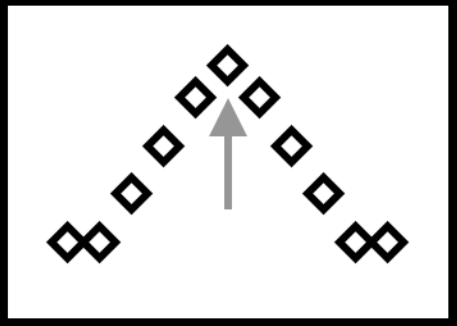


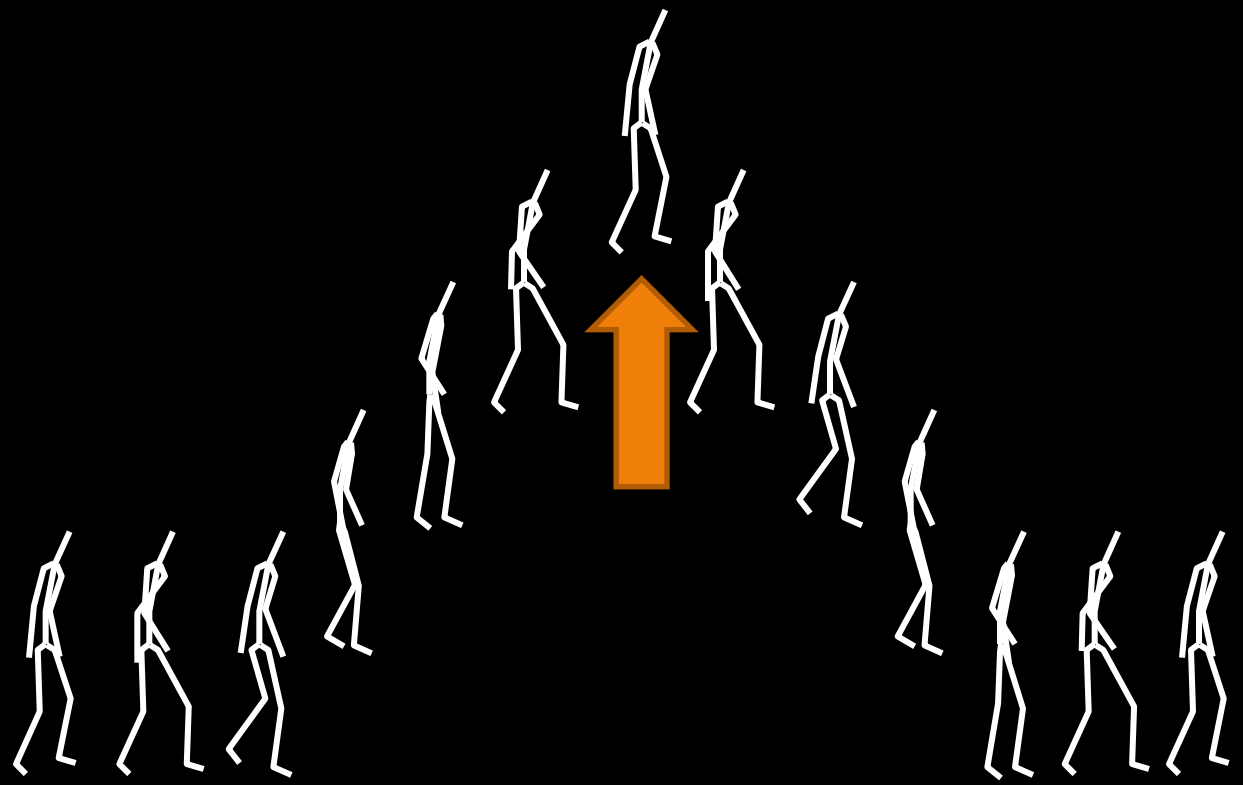


Motion Warp
Motion Displacement Map









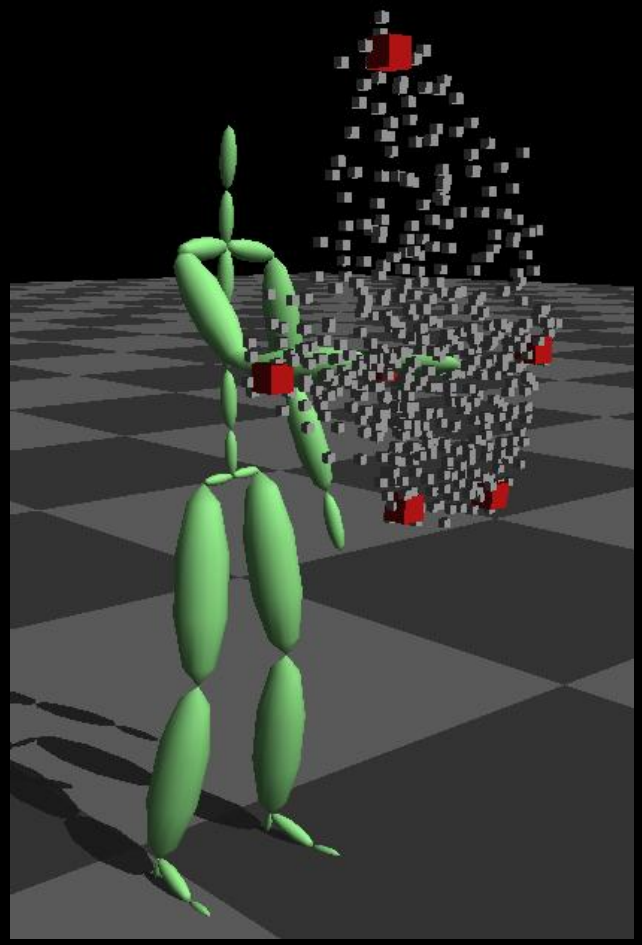
Blending is useful for:

Parametric Families

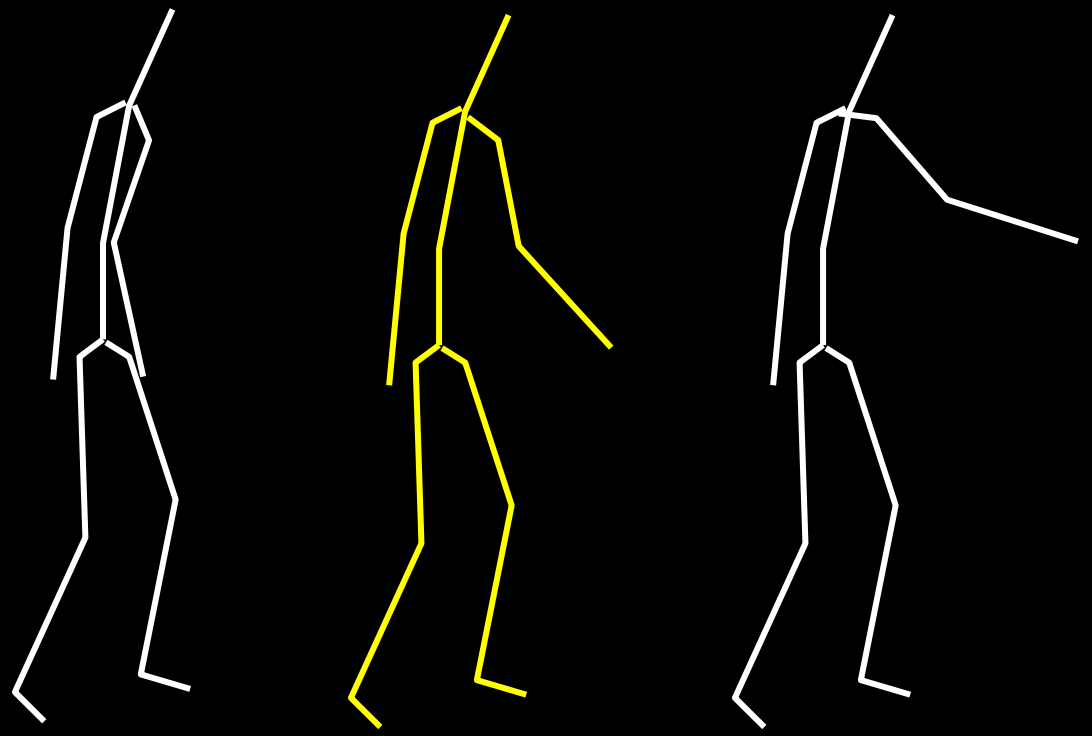
- Motions in-between examples

- Control by blend weights

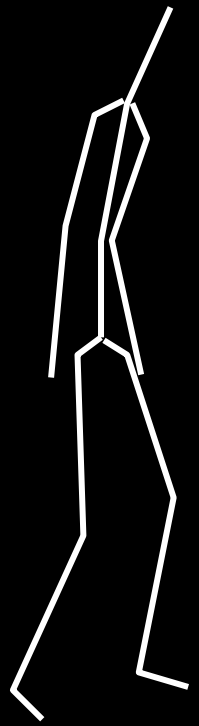
$$q(t) = \sum w_i \, q_i(\mathrm{t})$$

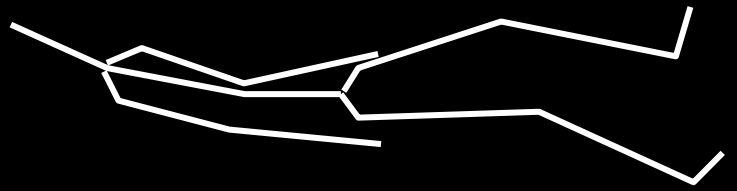


Need Similar **Poses**

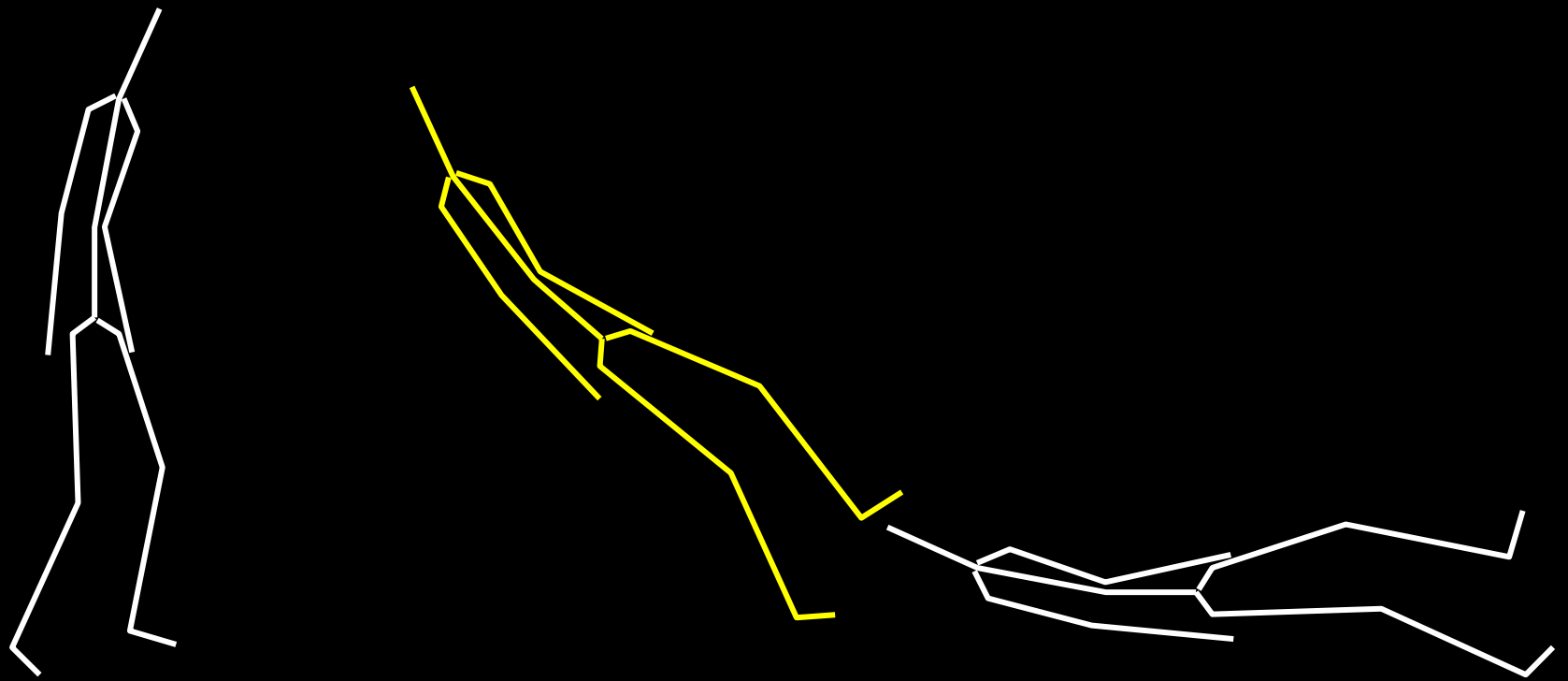


Need Similar **Poses**





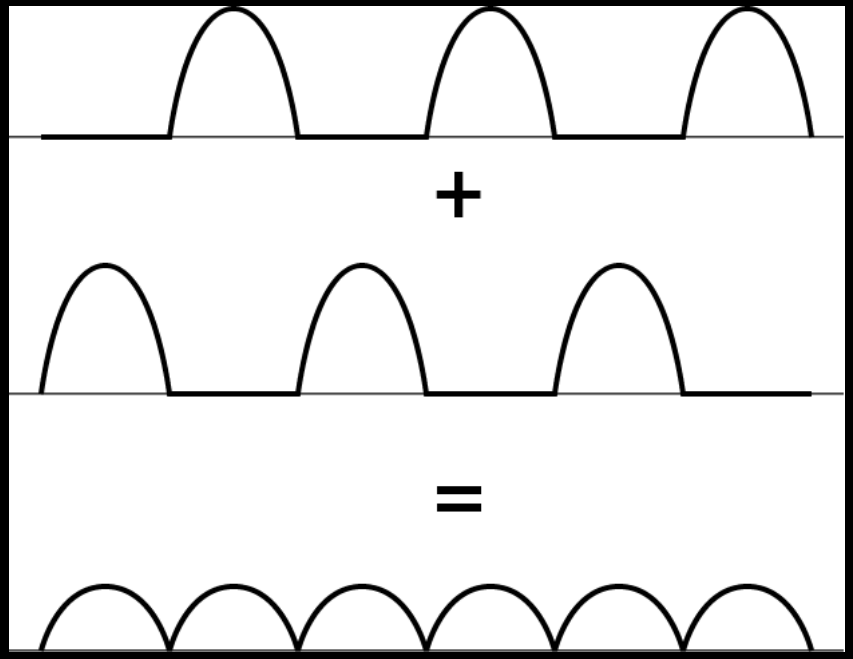
Need Similar **Poses**



No semantics – just numbers

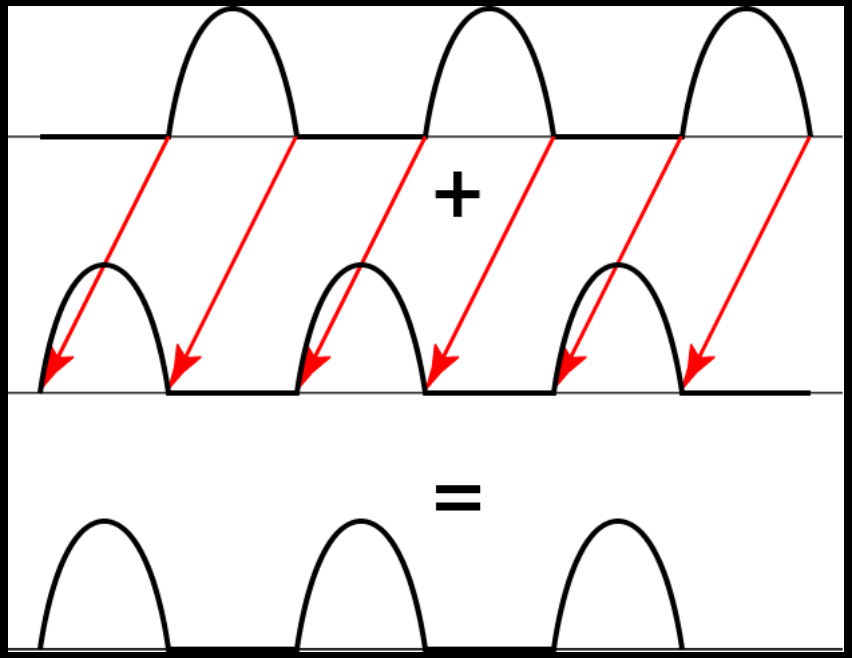
Blending requires similar motions

- Must be similar over entire clip

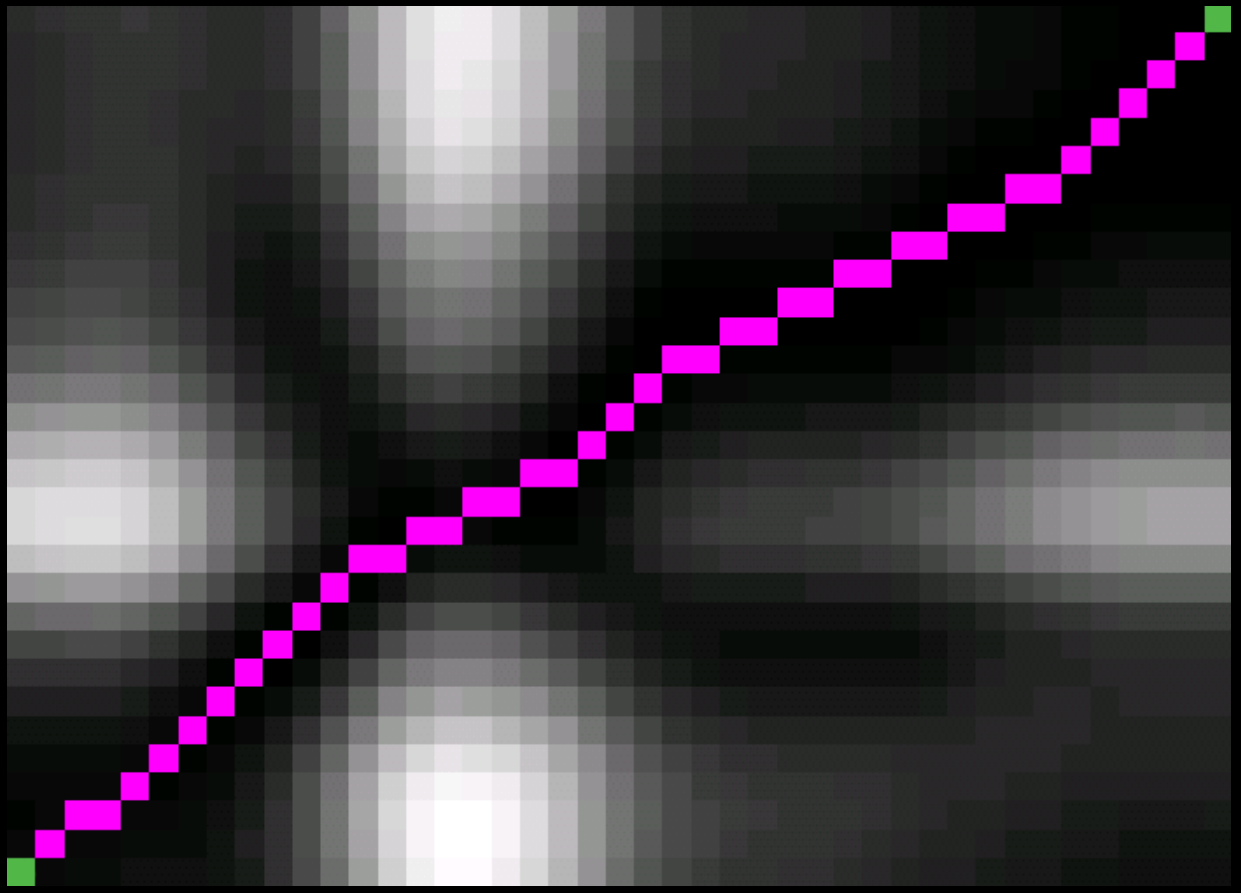


Align similar frames

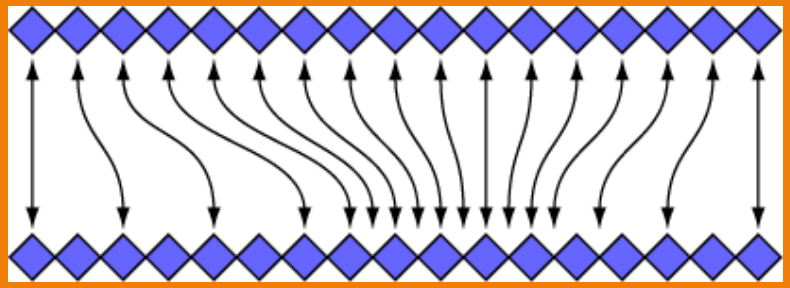
- Find matching frames
- Create timewarp
- Make motions similar



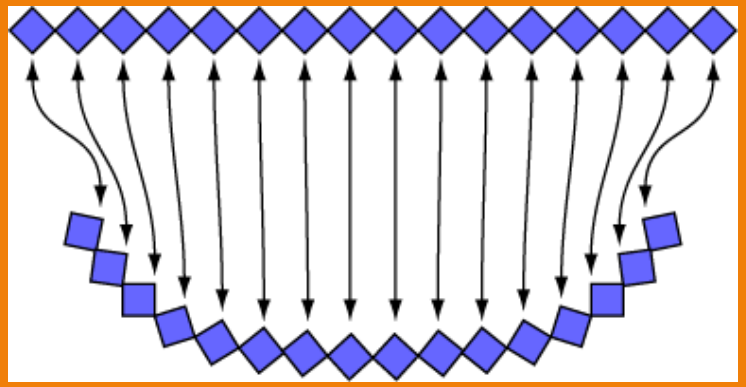
Dynamic Timewarping



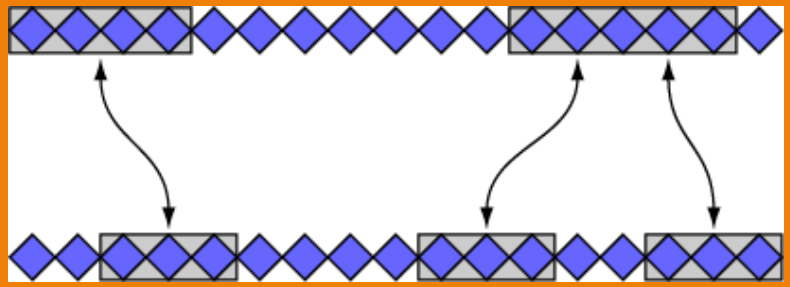
Blending requires similar motions



Different Timing



Different Curvature



Different Constraints

Why It Is Hard to Find Motions

- Motions can be different lengths.

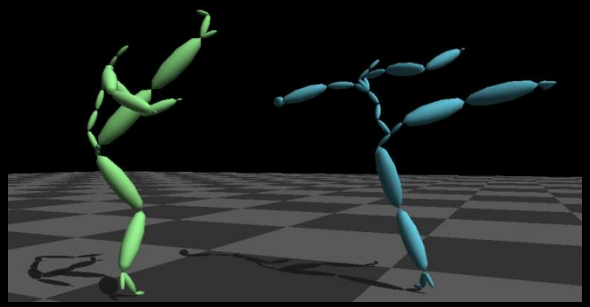
reach middle 

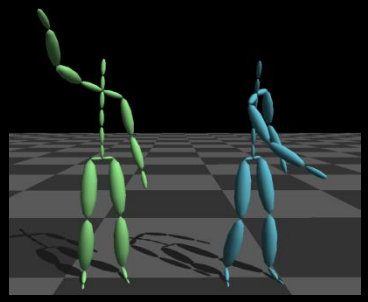
reach high 

- Complicated distance metrics

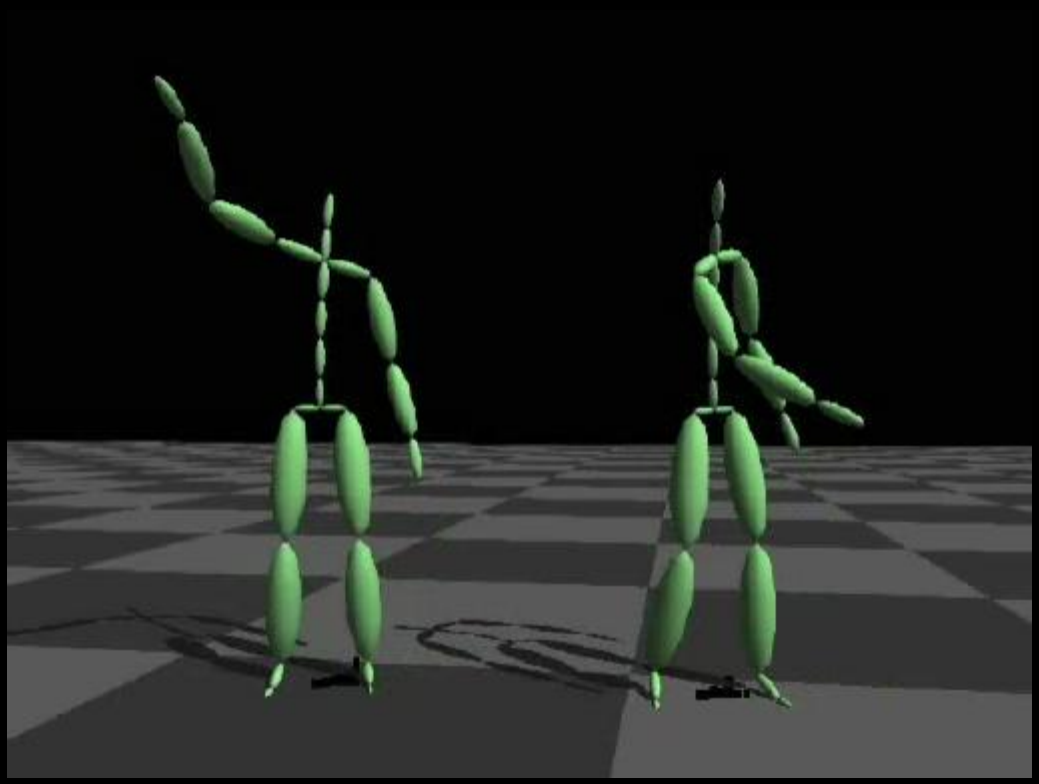
$$D(F, F') = \min_{\theta, x_0, z_0} \sum_i \left\| p_i - T(\theta, x_0, z_0) p_i' \right\|^2$$

- Logically similar ≠ numerically similar.



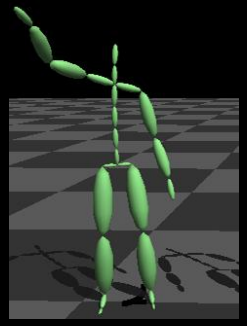
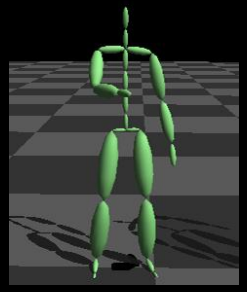
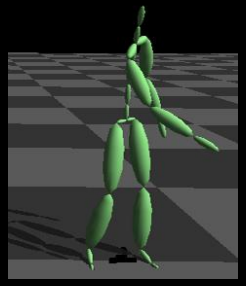


Similar?



Search Strategy

Find “close” matches and use as new queries.

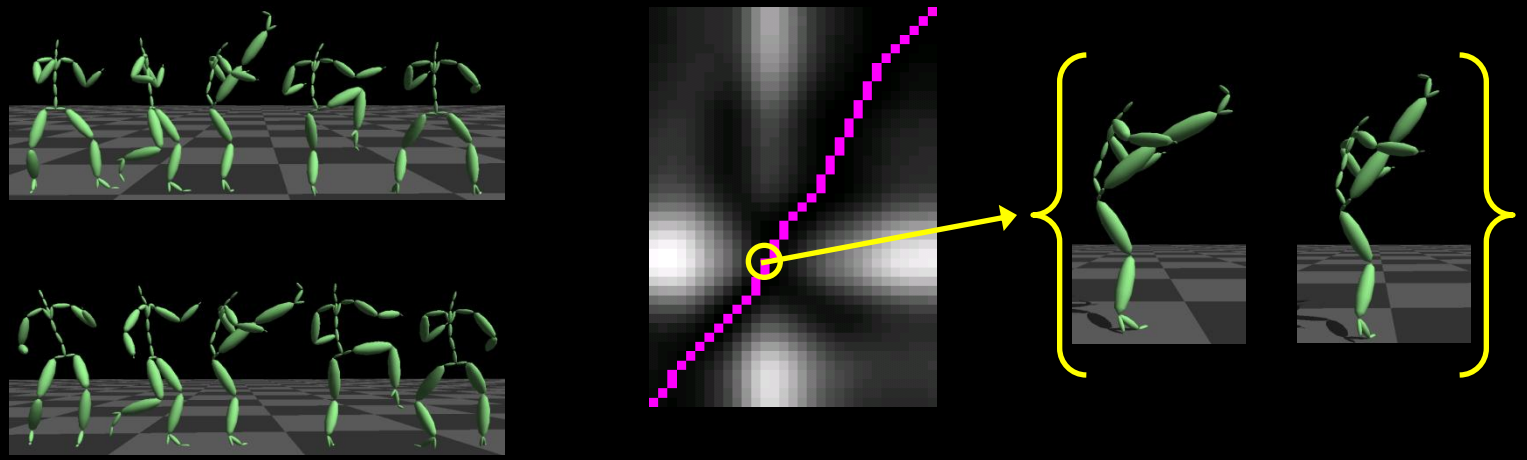
One search may involve many queries.

Precompute potential matches for interactivity.

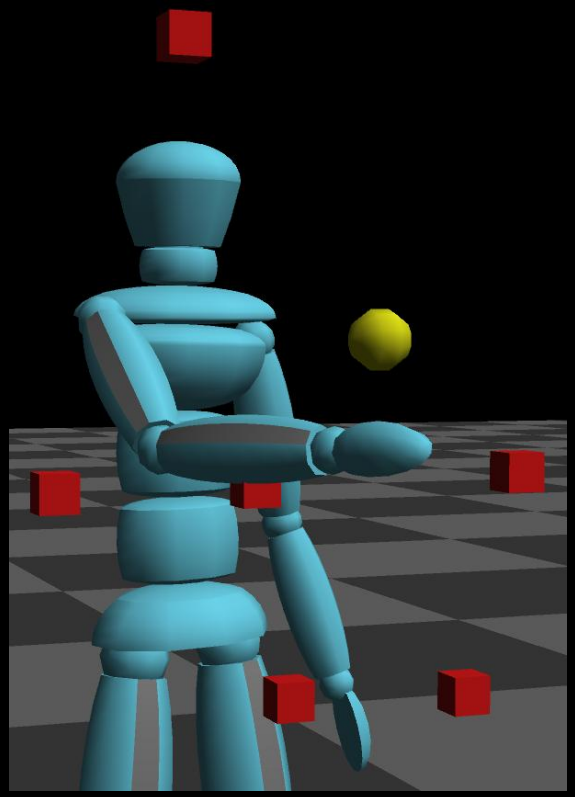
Computing Distance Between Motions

Distance between corresponding frames (in the best time warp)

- Factors out timing differences
- Allows arbitrary distance metrics for frames



What amounts to blend?



- Continuous control by blend weights
- Not what we want to control
- Irregular or Large Sample Sets
- Non-linear functions

Natural Parameterizations

Blend weights offer poor controls

We need more natural parameters.

$$g(M) = p$$

motion parameters

reaching	hand position at apex
turning	change in hip orientation
jumping	max height of center of mass

From Parameters to Blend Weights

It is easy to map blend weights to parameters.

$$\mathrm{f}(\mathbf{w}) = g(\underbrace{w_1\mathbf{M}_1 \oplus \ldots \oplus w_n\mathbf{M}_n}_{\text{blend}}) = \mathbf{p}$$

blend weights — blend — parameters

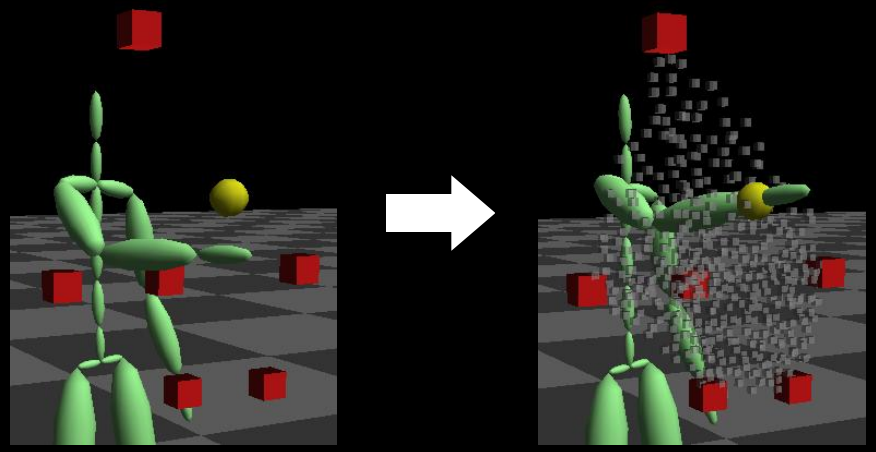
But we want $w=f^{-1}(p)$!

This has no closed form solution!

Building Parameterizations

Given samples (p,w), we can approximate f^{-1} with k-nearest neighbor interpolation.

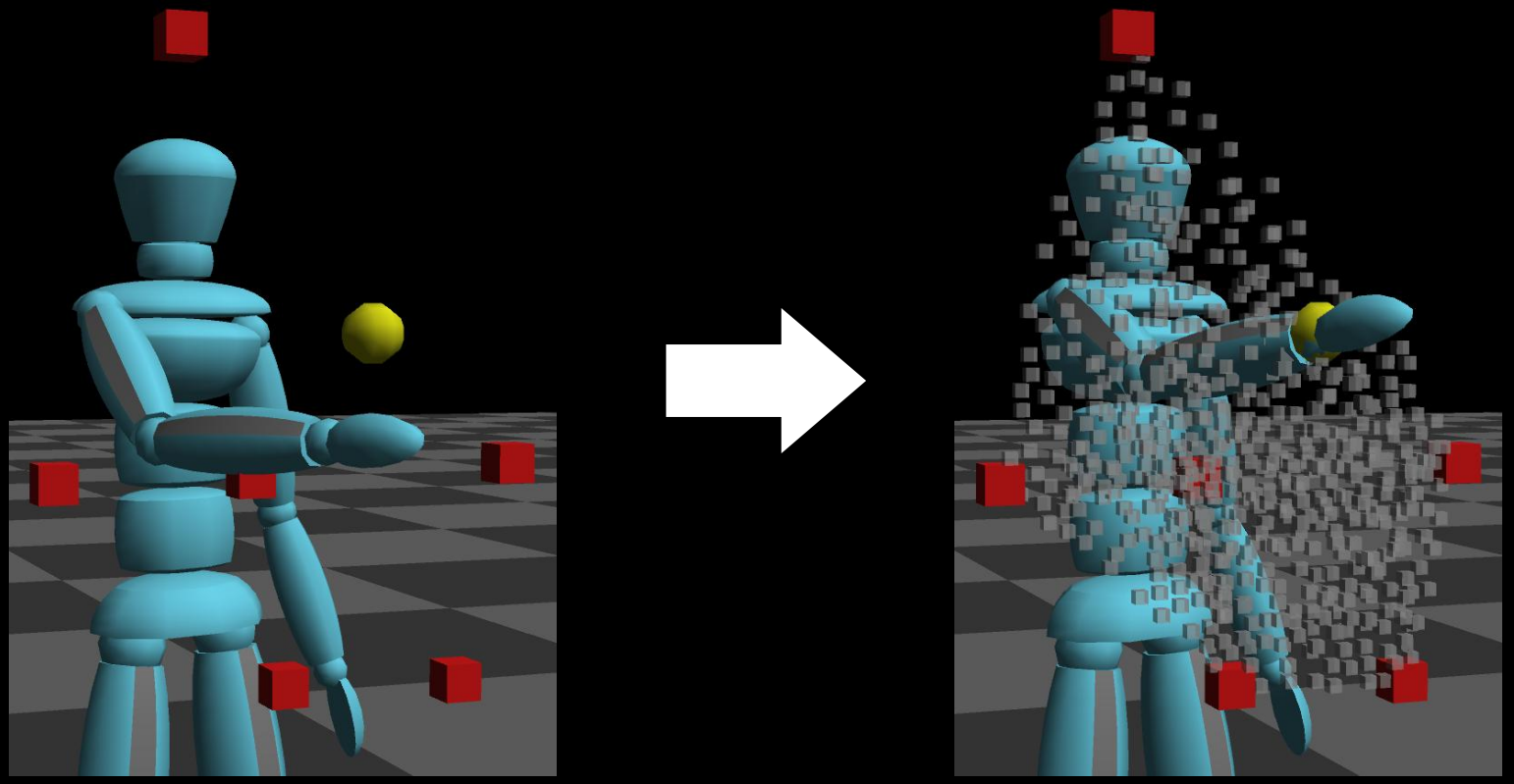
Accuracy: create new blends to get additional



Require "reasonable": $\sum_i w_i = 1$

$$-\varepsilon \le w_i \le 1+\varepsilon$$

What amounts to blend?



- Automatically map controls to blend weights
- Sampling + Scattered Data Interpolation