Motion Capture
Part 2

Computer Graphics

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Manipulating Motion Data

- Adjusting
- Blending
- Transitioning
- Retargeting

Adjusting

Why is this task not trivial?

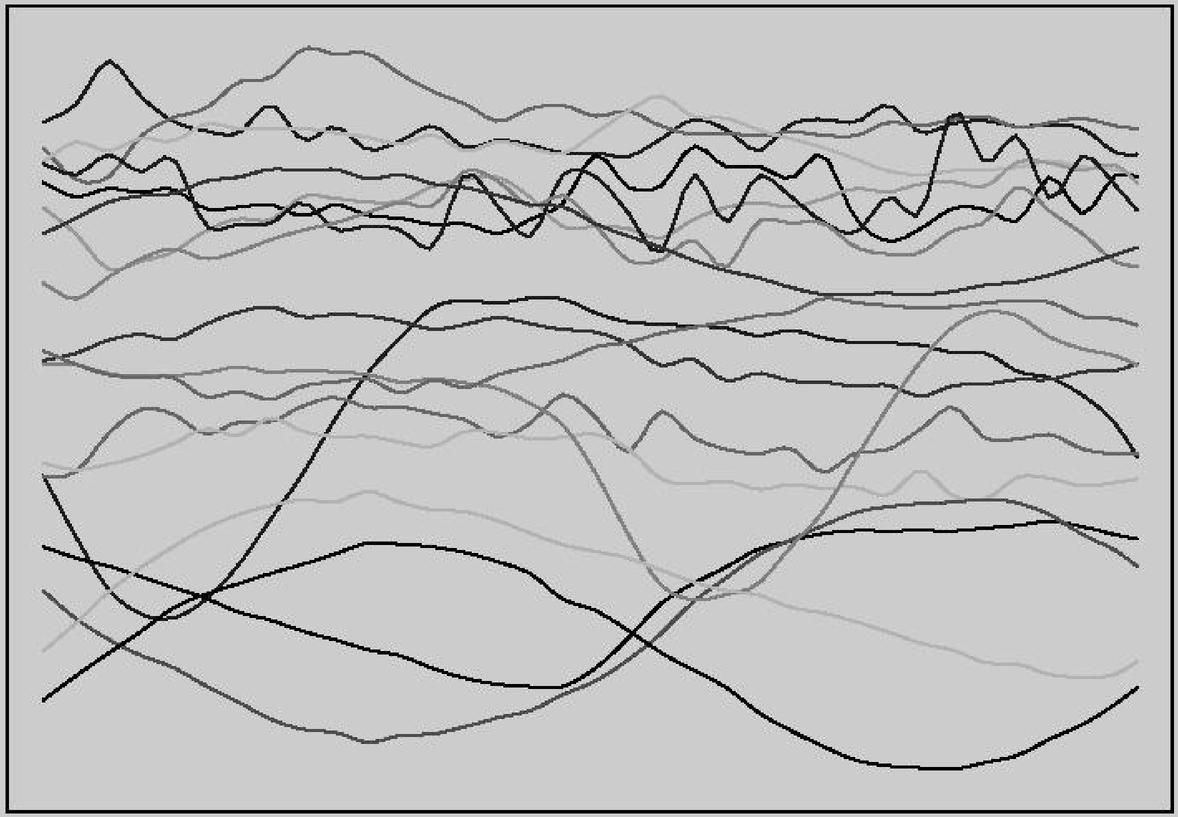
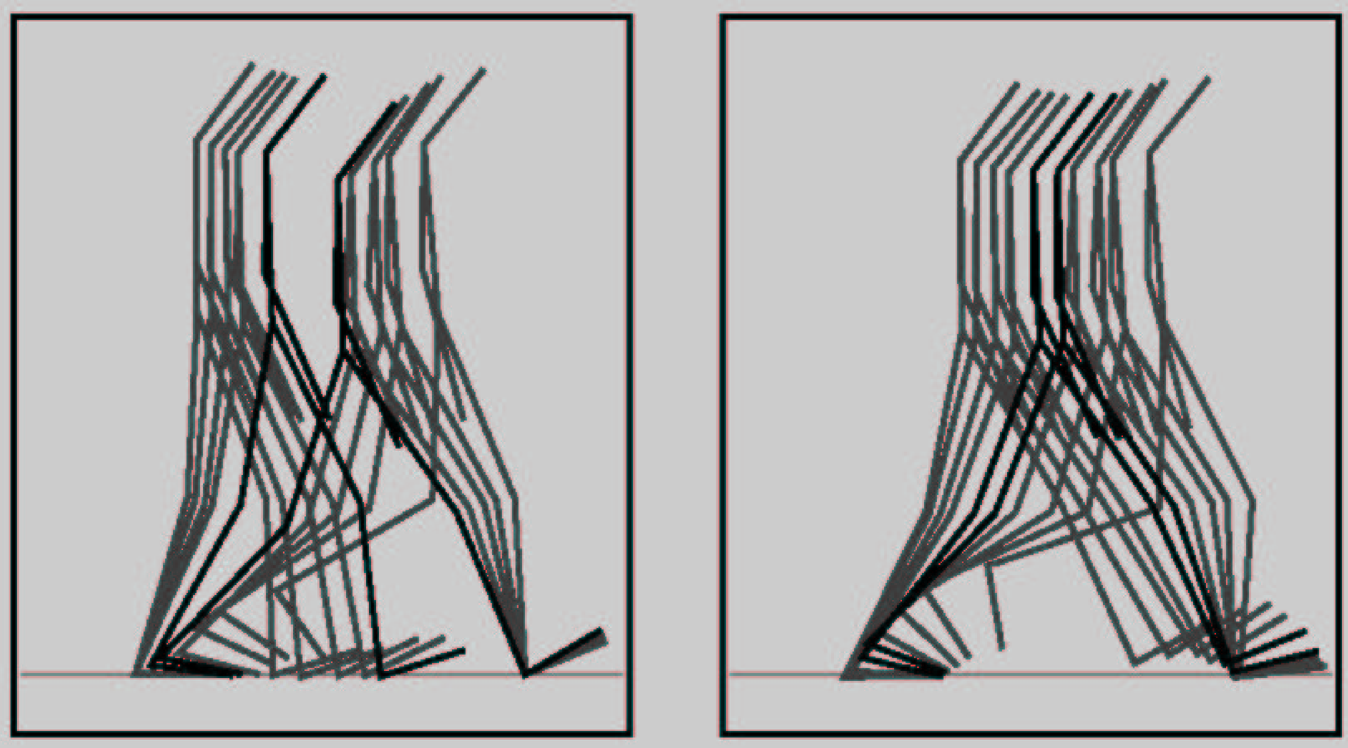


Figure 1: Some of the captured motion curves of human walking.

From Witkin and Popovic, SIGGRAPH 95

Adjusting

IK on single frames will not work



From Gleicher, SIGGRAPH 98

Adjusting

Define desired function with

$$\boldsymbol{m}(t) = \boldsymbol{m}_0(t) + \boldsymbol{d}(t)$$

Adjustment

Inital sampled data

Result after adjustment

Adjusting

$$\boldsymbol{d} \in \text{“Some nice space”}$$

For example use b−splines or Gaussian bumps

The idea is to spread modification over a reasonable period of time

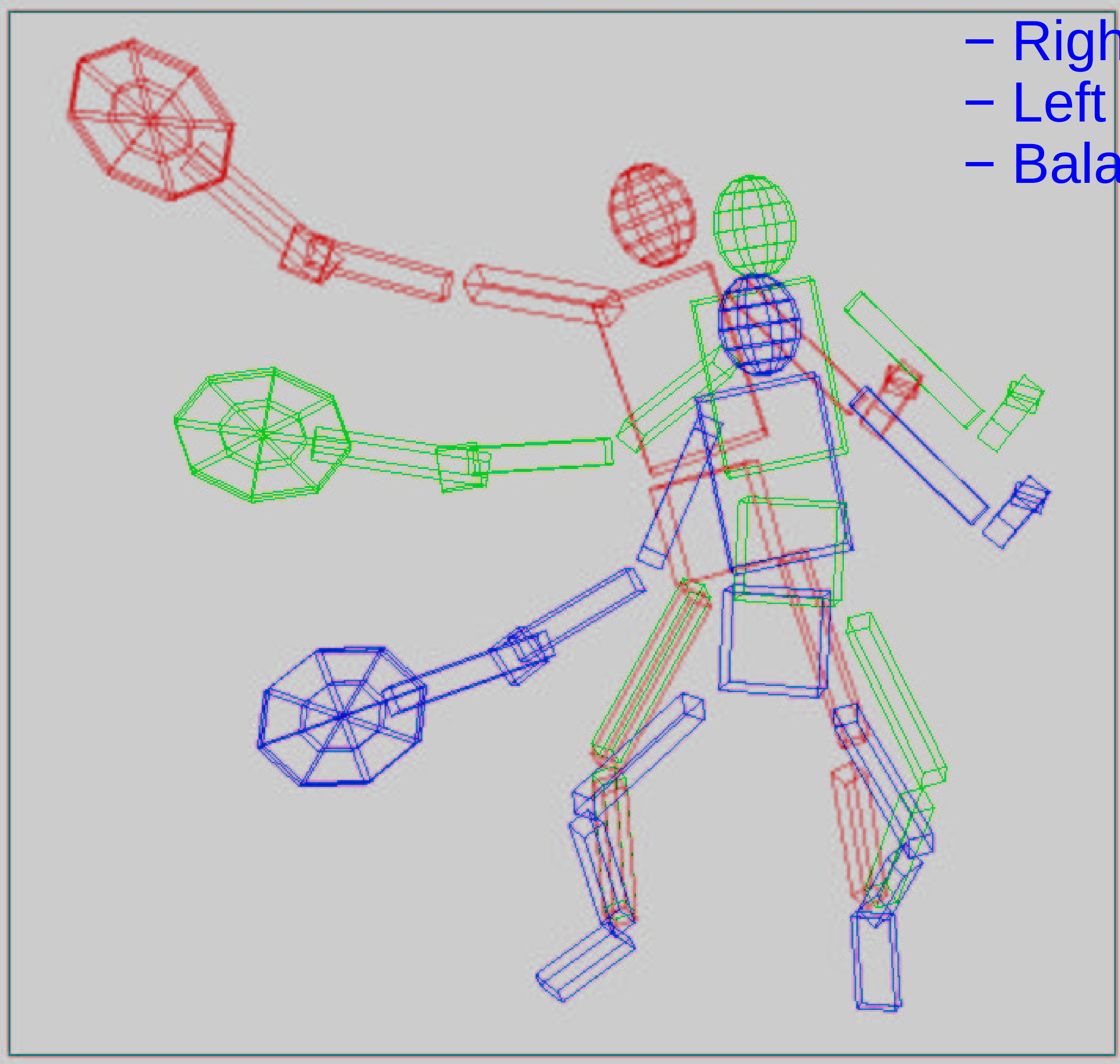
Support radius picked to match what user defines as reasonable

$$\boldsymbol{d}(t) = \sum_{i=1}^{n} \boldsymbol{c}_i b_i(t)$$

Adjusting

How would we do the IK?

- Racket position
- Right foot fixed
- Left toes fixed
- Balance



From Witkin and Popovic, SIGGRAPH 95

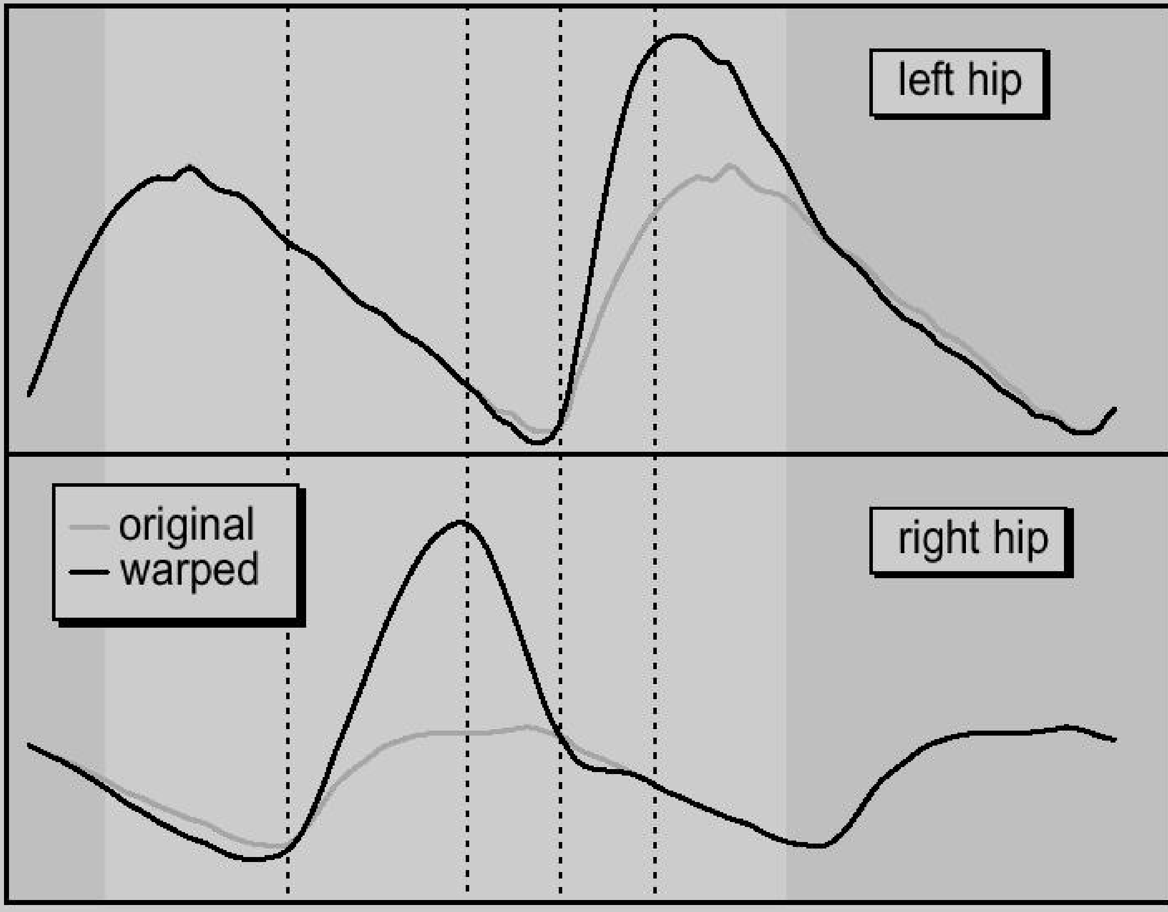
Adjusting

Use IK to solve for $\boldsymbol{d}$ at time t_i

Select control points for function so that

$$\boldsymbol{d}(t_i) = \boldsymbol{d}^{t_i}$$

Adjusting



From Witkin and Popovic, SIGGRAPH 95

What if adjustments overlap?

Adjusting

Extend FK to include time

$$
\begin{aligned}
p^{t_i} &= K_p(\boldsymbol{m}(t_i)) \\
&= K_p(\boldsymbol{m}_0(t_i) + \boldsymbol{d}(t_i)) \\
&= K_p\left(\boldsymbol{m}_0(t_i) + \sum_{j=1}^{n} \boldsymbol{c}_j b_j(t_i)\right)
\end{aligned}
$$

Adjusting

Do IK to find control values

$$\mathrm{d}p^{t_i} = J_{p/\boldsymbol{m}} \cdot \mathrm{d}\boldsymbol{m}$$

$$= J_{p/\boldsymbol{m}} \cdot J_{\boldsymbol{m}/\boldsymbol{c}} \cdot \mathrm{d}\boldsymbol{c}$$

Assemble all constraints into one system

Blending

If given two motions, can we blend them to find a motion 1/2 between them?

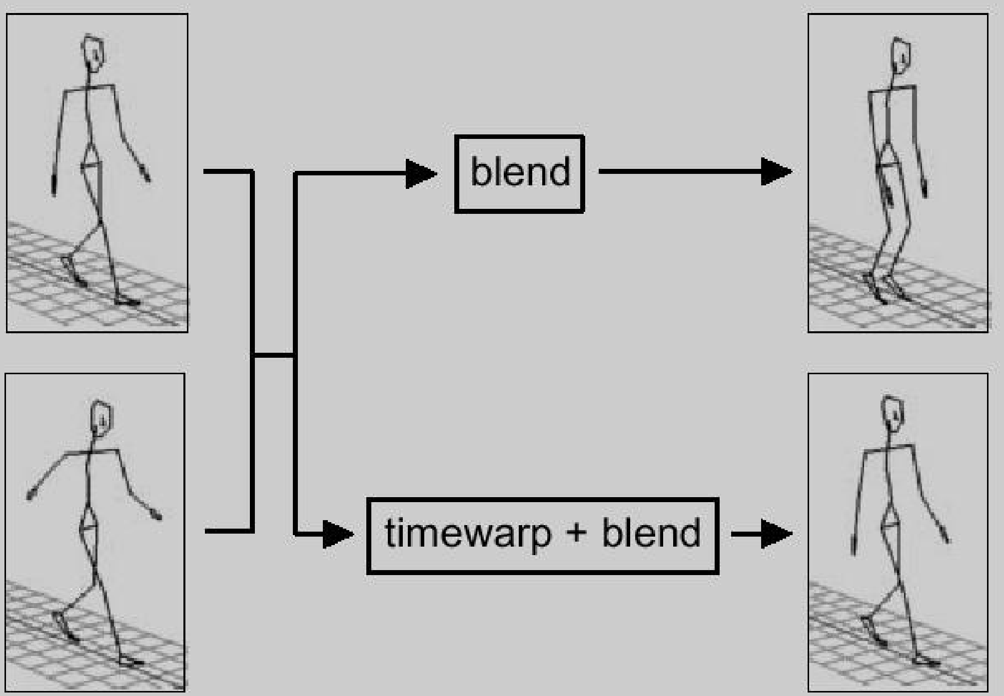
$$\boldsymbol{m}_\alpha(t) = \alpha \boldsymbol{m}_a(t) + (1 - \alpha)\boldsymbol{m}_b(t)$$

Assume same DOFs

Assume same parameter mappings

Blending

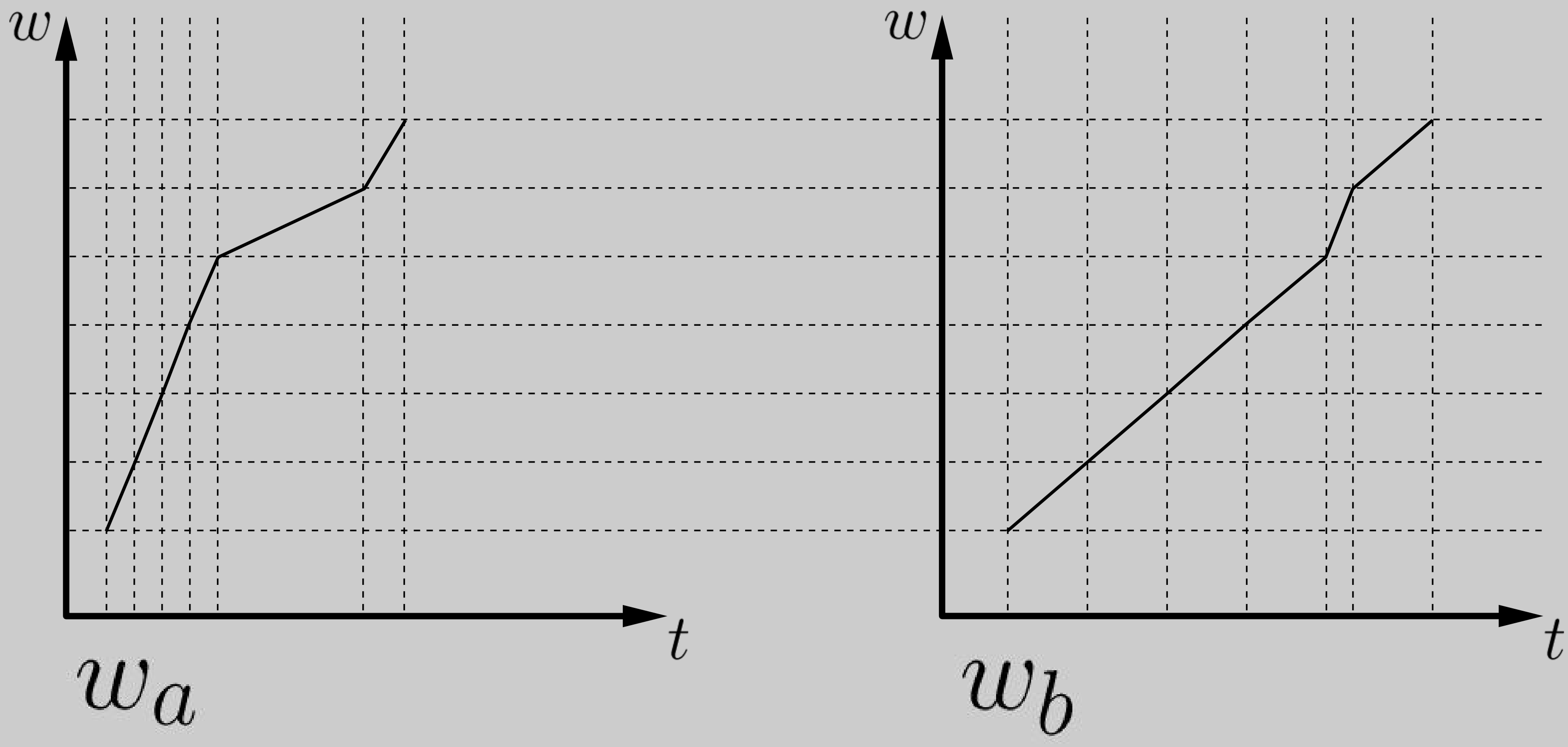
Consider something simple: fast and slow walks



From Bruderlin and Williams, SIGGRAPH 95

Blending

Define timewarp functions



Blending

Blend in normalized time

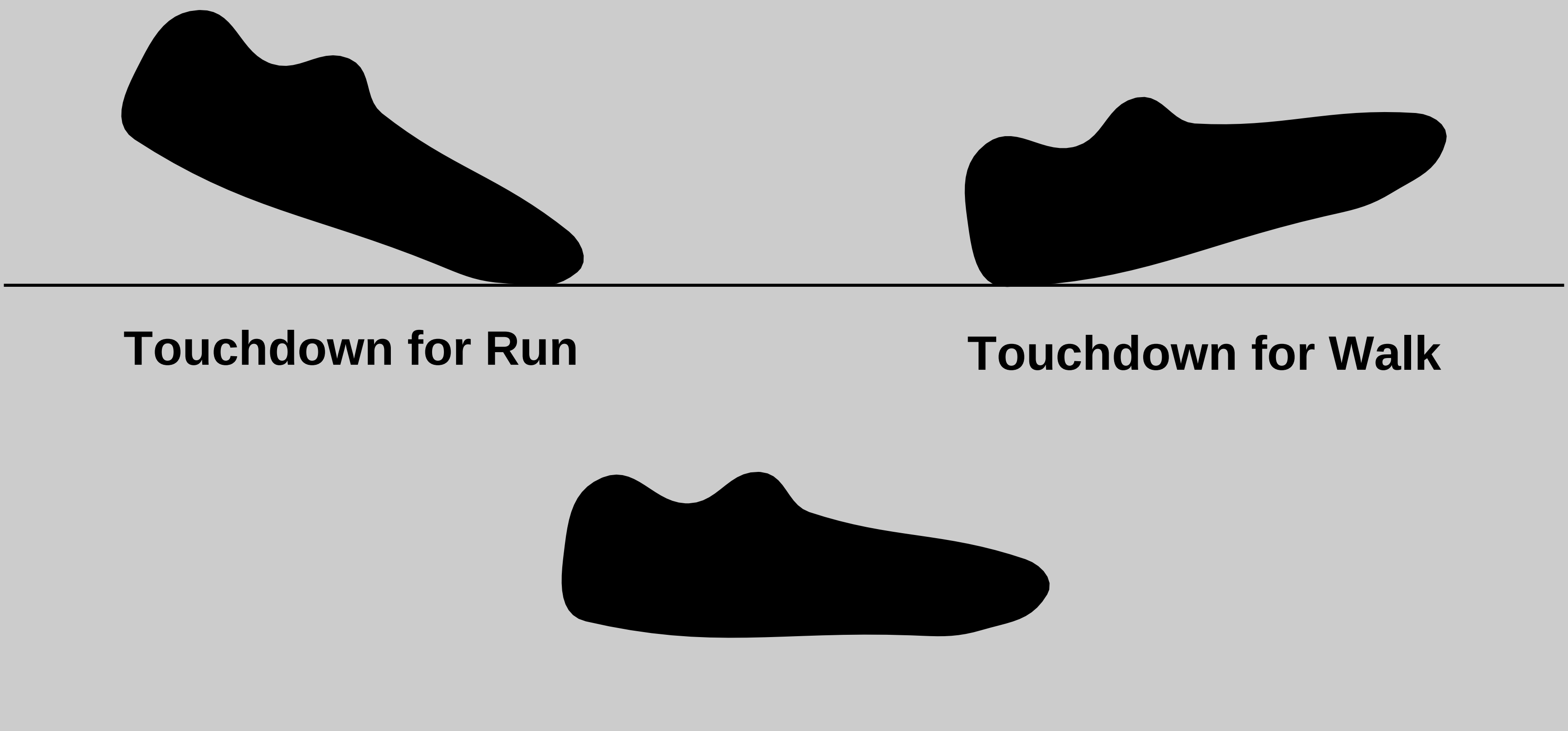
$$\boldsymbol{m}_\alpha(w) = \alpha \boldsymbol{m}_a(w_a) + (1-\alpha)\boldsymbol{m}_b(w_b)$$

Blend playback rate

$$\frac{\mathrm{d}t}{\mathrm{d}w} = \alpha \frac{\mathrm{d}t}{\mathrm{d}w_a} + (1-\alpha)\alpha \frac{\mathrm{d}t}{\mathrm{d}w_b}$$

Blending

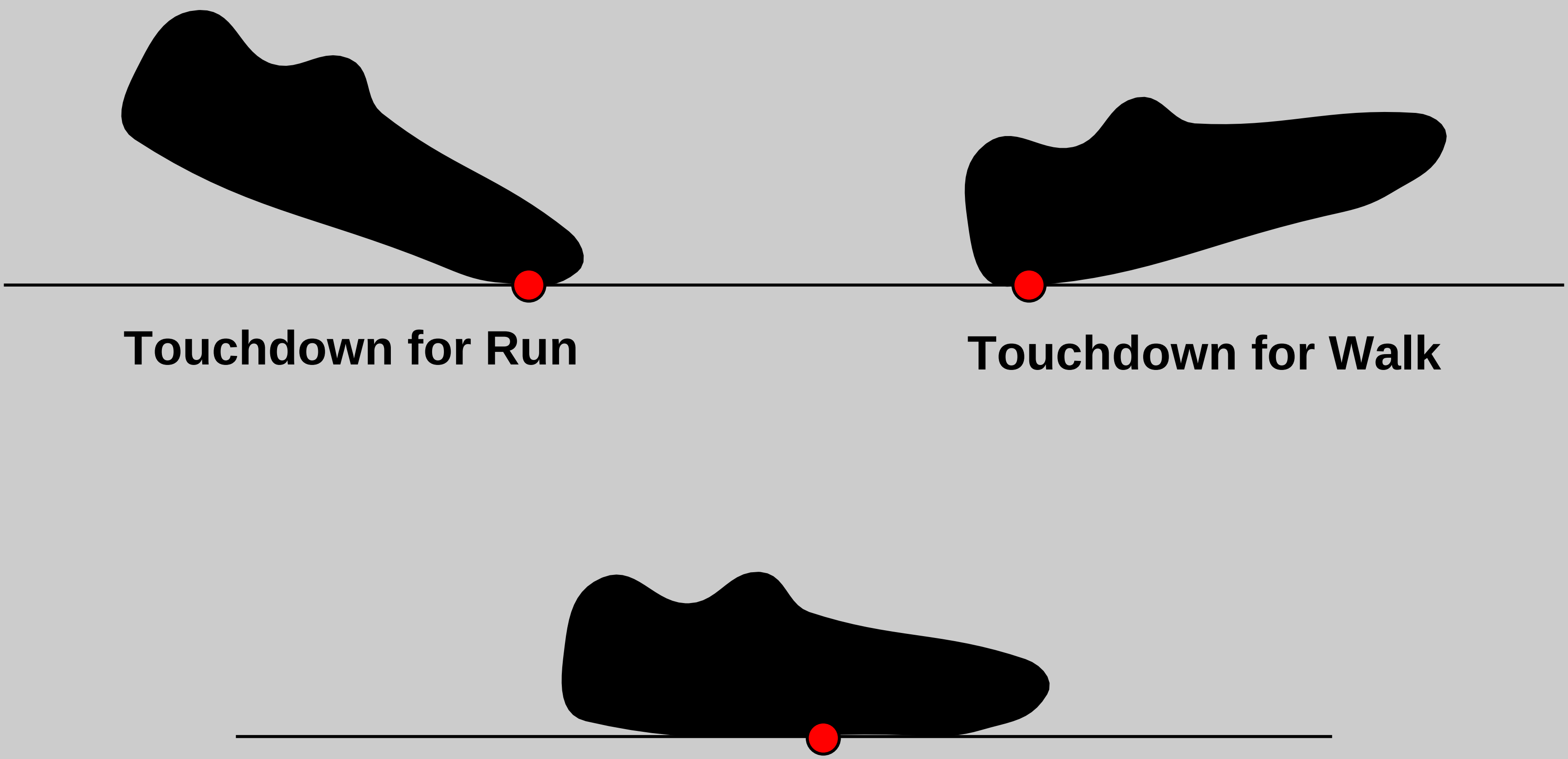
Blending may still break "features" in original motions



Blend misses ground and floats

Blending

Add explicit constraints to key points



Blending

Add quality metric on $\boldsymbol{d}(t)$

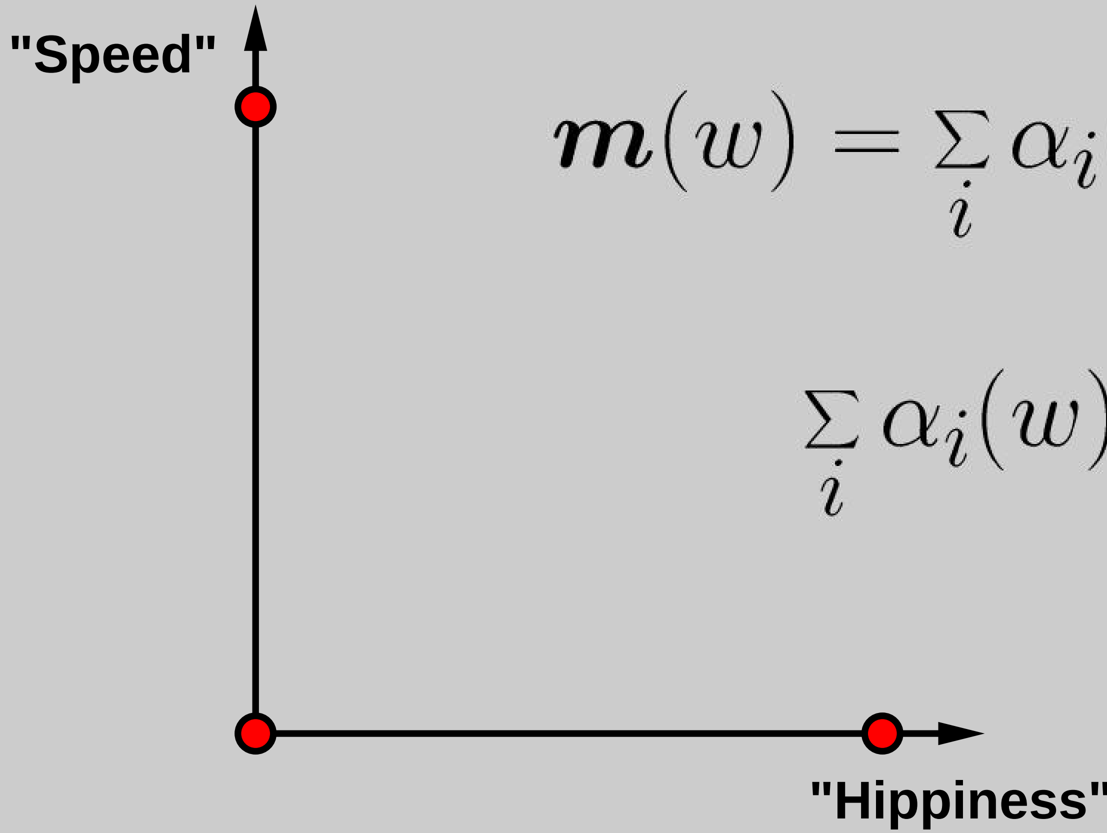
Minimize accelerations/torques

Explicit smoothness

Other criteria...

Blending

Extend to multivariate interpolation



$$\boldsymbol{m}(w) = \sum_i \alpha_i(w)\, \boldsymbol{m}_i(w)$$

$$\sum_i \alpha_i(w) = 1$$

Weights are now barycentric coordiantes

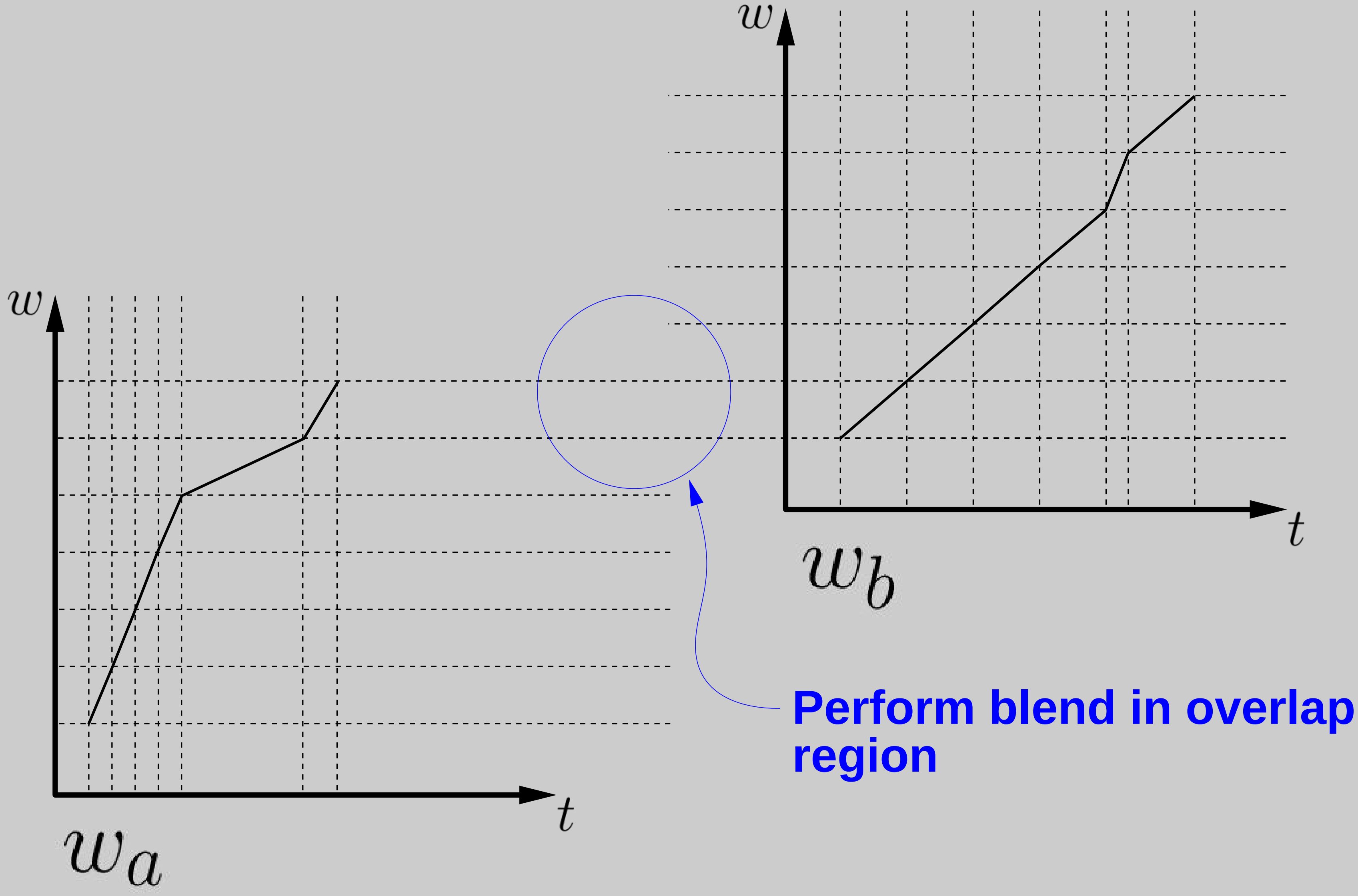
Blending

Extend to multivariate interpolation

Becomes standard interpolation problem...

Transitioning

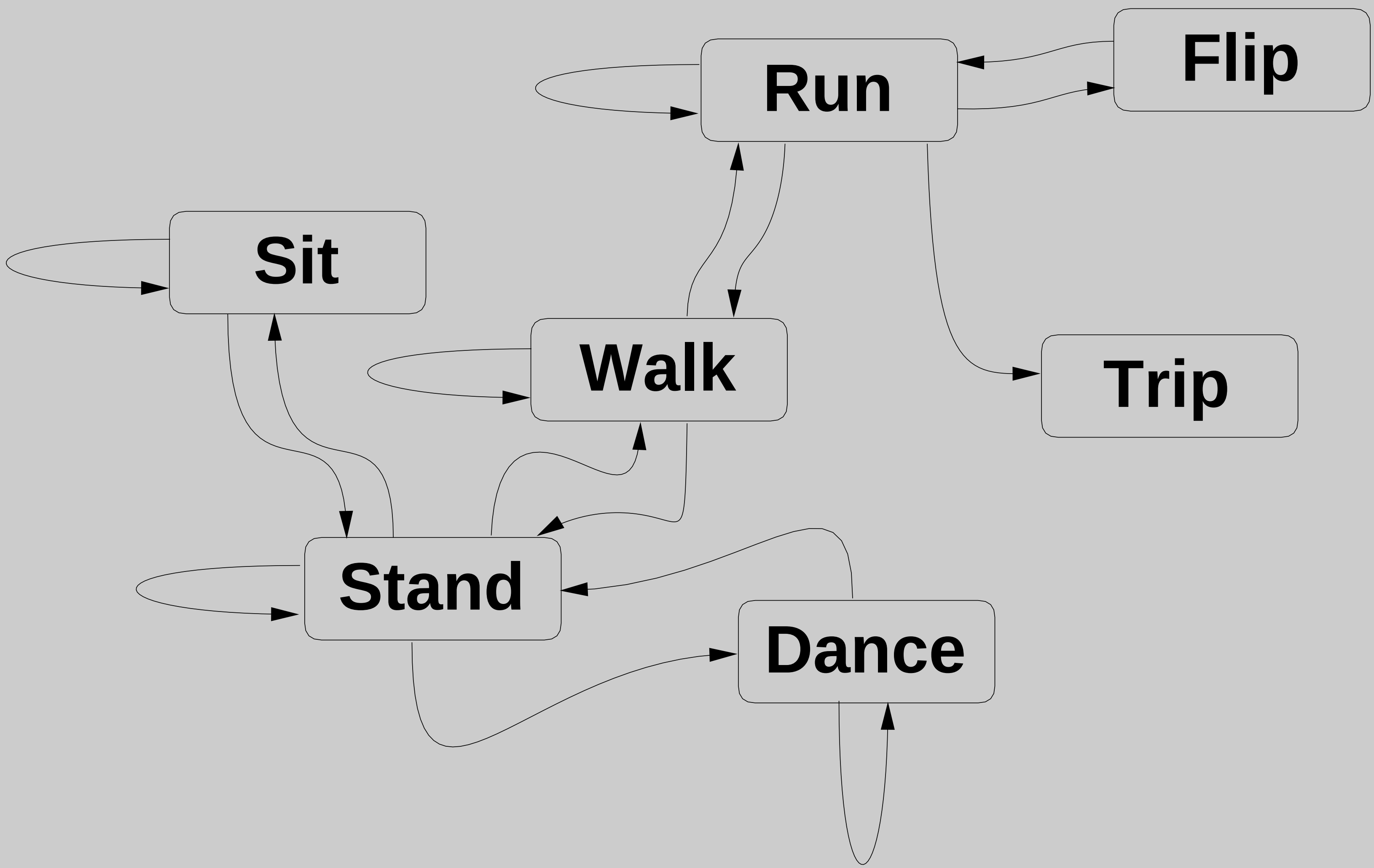
Transition from motion A to motion B



Cyclification

- Special case of transitioning
- Both motions are the same
- Need to modify beginning and ending simultaneously

Transition Graphs



Retargeting

Adapt motion to another character

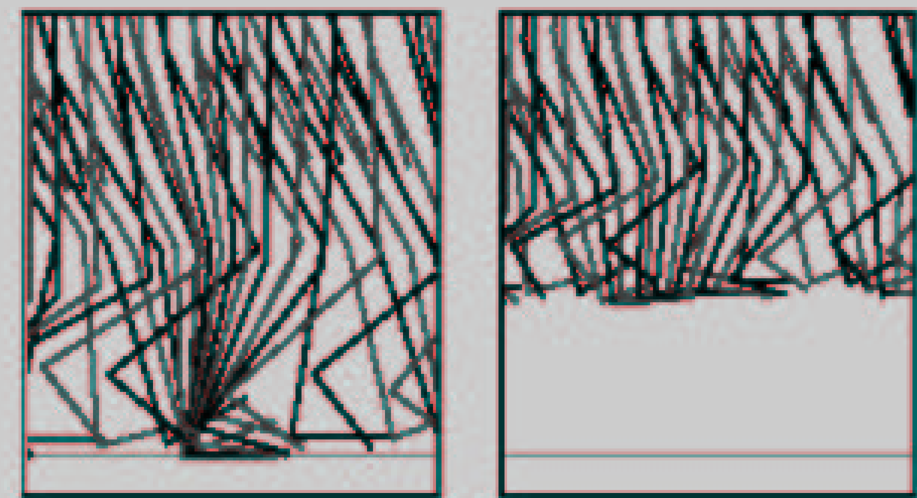


Figure 2: Left: Frames from a rotoscoped walking motion are shown. Right: Applying this motion to a character that is 60% of the size of the original yields a motion that skates along horizontally above the floor.

From Gleicher, SIGGRAPH 98

Use IK across samples, similar to adjusting

Retargeting

Allow optimization of constraint parameters

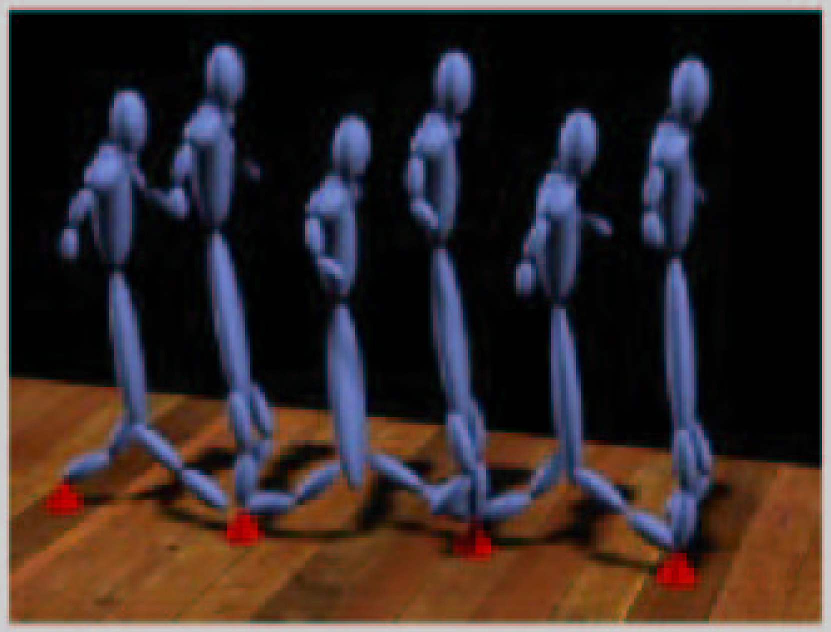
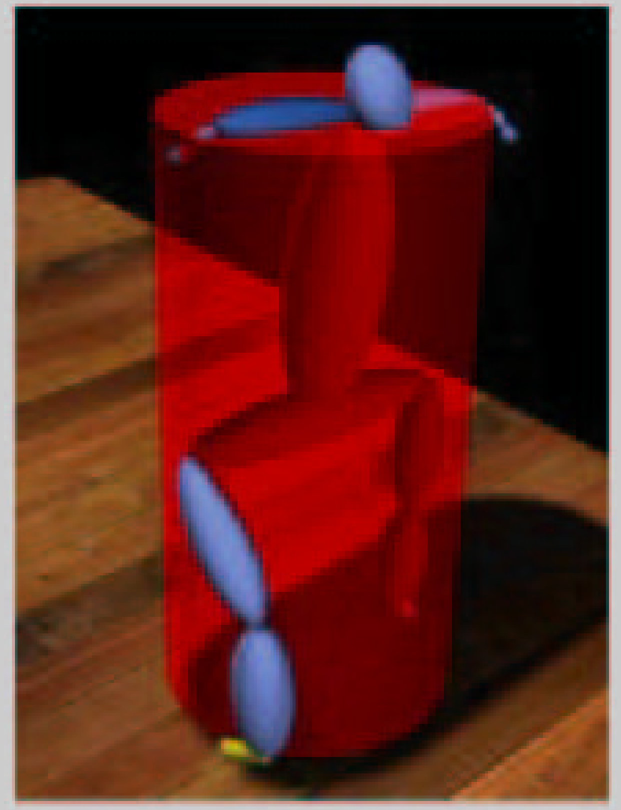


Figure 8: Forcing a character with short legs to walk in the footsteps of a longer-legged character leads to an unnatural motion.

From Gleicher, SIGGRAPH 98

Retargeting



From Gleicher, SIGGRAPH 98

From Gleicher, SIGGRAPH 98

Suggested Reading

Fourier principles for emotion−based human figure animation
Munetoshi Unuma, Ken Anjyo and Ryozo Takeuchi
SIGGRAPH 95

Motion signal processing
Armin Bruderlin and Lance Williams
SIGGRAPH 95

Motion warping
Andrew Witkin and Zoran Popovic
SIGGRAPH 95

Efficient generation of motion transitions using spacetime constraints
Charles Rose, Brian Guenter, Bobby Bodenheimer and Michael F. Cohen
SIGGRAPH 96

Retargetting motion to new characters
Michael Gleicher
SIGGRAPH 98

Verbs and Adverbs: Multidimensional Motion Interpolation
Rose, Cohen, and Bodenheimer
IEEE: Computer Graphics and Applications, v. 18, no. 5, 1998