Motion Blending

(Interpolation and Timewarping)

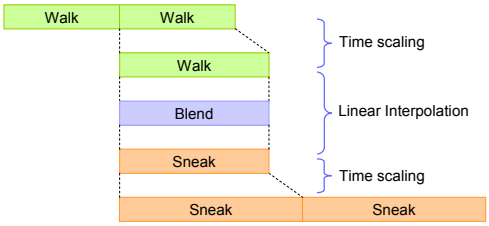
Jehee Lee

Blending for Smooth Transition

- **Case study: walk-to-sneak**
  - Transit smoothly over one cycle of locomotion
  - "Walk" is faster than "sneak"
  - One cycle of "sneak" is longer than one cycle of "walk"

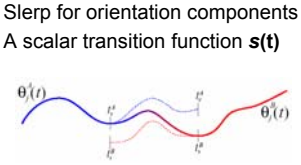
Blending for Smooth Transition

- **Blend over the overlapping time interval**

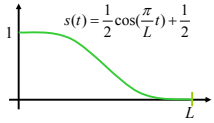


Blending for Smooth Transition

- **Linear interpolation between motions**
  - Slerp for orientation components
  - A scalar transition function ***s(t)***

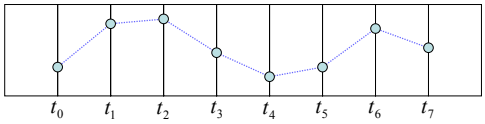


$$s(t)\cdot \mathbf{m}^A(t) \oplus (1-s(t))\cdot \mathbf{m}^B(t)$$



Time Scaling

- **Uniform resampling**
  - Motion data may be given as a sequence of discrete frames
  - It can be considered as a piecewise linear signal



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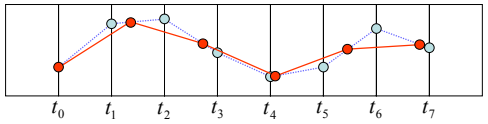
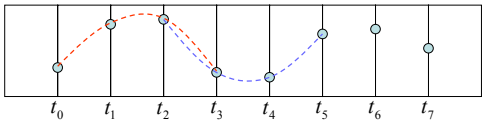


$$\mathbf{m}(t) = (1-\alpha)\mathbf{m}(t_i) \oplus \alpha\mathbf{m}(t_{i+1}), \quad \text{where} \quad \alpha = \frac{t-t_i}{t_{i+1}-t_i}$$

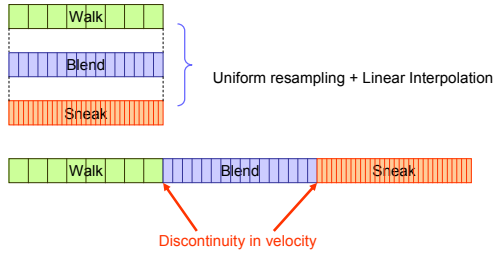
Time Scaling

- **Cubic resampling**
  - piecewise cubic interpolation



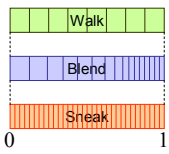
Time Scaling

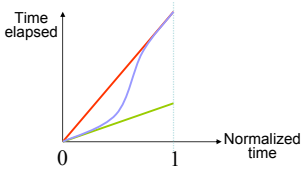
- **Discontinuity in velocity**



Time Scaling

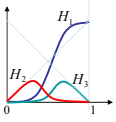
- **Non-uniform resampling**





$$T(t) = H_1(t) + H_2(t) f_1 + H_3(t) f_2$$

$$T(0) = 0, \quad T(1) = 1,$$
$$T'(0) = f_1, \quad T'(1) = f_2$$

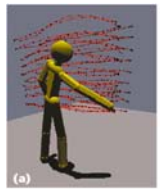


$$H_1(t) = -2t^3 + 3t^2$$
$$H_2(t) = t^3 - 2t^2 + t$$
$$H_3(t) = t^3 - t^2$$

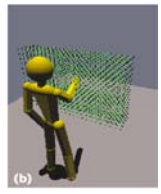
Interpolating Poses

- **Parameterize poses by hand positions**
  - Tri-linear interpolation
  - Data-driven inverse kinematics

[Wiley & Hahn 97]



Initial data



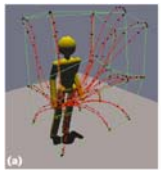
Resampled data

Data-driven IK

Interpolating Motions

- **Blending similar actions**
  - Good correspondences among motions are assumed
  - Time correspondences
  - Spatial alignment

[Wiley & Hahn 97]



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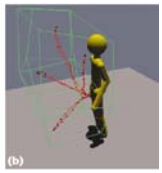


Interpolated data

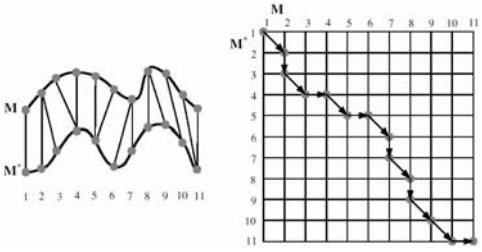
Dynamic Time Warping

- **The vertex correspondence problem**
  - Minimize the sum of distances between corresponding vertices
  - The correspondence must be continuous
    - No missing vertices
    - No cross edges (No turning back in time)

Dynamic Time Warping

- **Find a chain from top-left to bottom-right**
  - Allowed to move horizontally, vertically, or diagonally

$$M_{i,j} = \min\left(M_{i-1,j-1}, M_{i-1,j}, M_{i,j-1}\right) + d_{i,j}$$



Distance between Poses

- **Weighted differences between joint angles**

$$d_{i,j} = \mathbf{w} \cdot \left(\mathbf{m}^A(t_i) \ominus \mathbf{m}^B(t_j)\right)$$

- **The sum of distances between points**

- **Should we consider velocities ?**

Spatial Alignment

- **The root segment needs special care**
  - The position and orientation of motions must be aligned properly before blending

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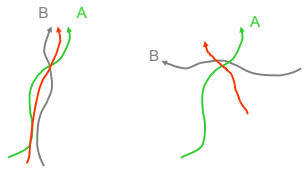
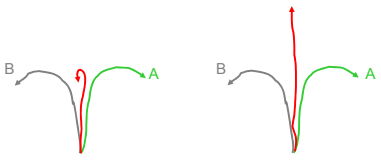


Spatial Alignment

- **The root segment needs special care**
  - The position and orientation of motions sometimes should be represented and blended with respective to body local coordinate system



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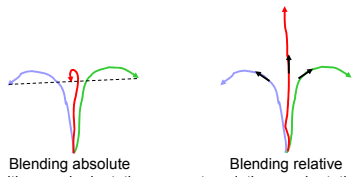

Blending absolute positions and orientations

Blending relative translations and rotations

Summary

- **Motions may be blended**
  - Over time, or
  - Over spatial domain
- **Motions to be blended must have good correspondences**
  - Time alignment
  - Spatial alignment