Movement and Artificial Intelligence

Programming with Motion Capture Data

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Course overview

- Motion representation
- Parsing mocap data and playing the motion
- Processing motion data
  - Editing: connecting motion segments, warping, blending, time scaling, etc.
  - Motion graph and transition graph
  - Motion Retargeting

Movement Definition

- Pose or configuration of an articulated figure
  - Positions: $\mathbf{p}(t)$ in $\mathbf{R}^3$ (in Euclidian vectorial space)
  - Orientations: $\mathbf{q}_i(t)$ in $\mathbf{S}^3$ (in SO3 space)

$$\mathbf{m}(t) = \begin{pmatrix} \mathbf{p}(t) \\ \mathbf{q}_0(t) \\ \mathbf{q}_1(t) \\ \vdots \\ \mathbf{q}_n(t) \end{pmatrix}$$

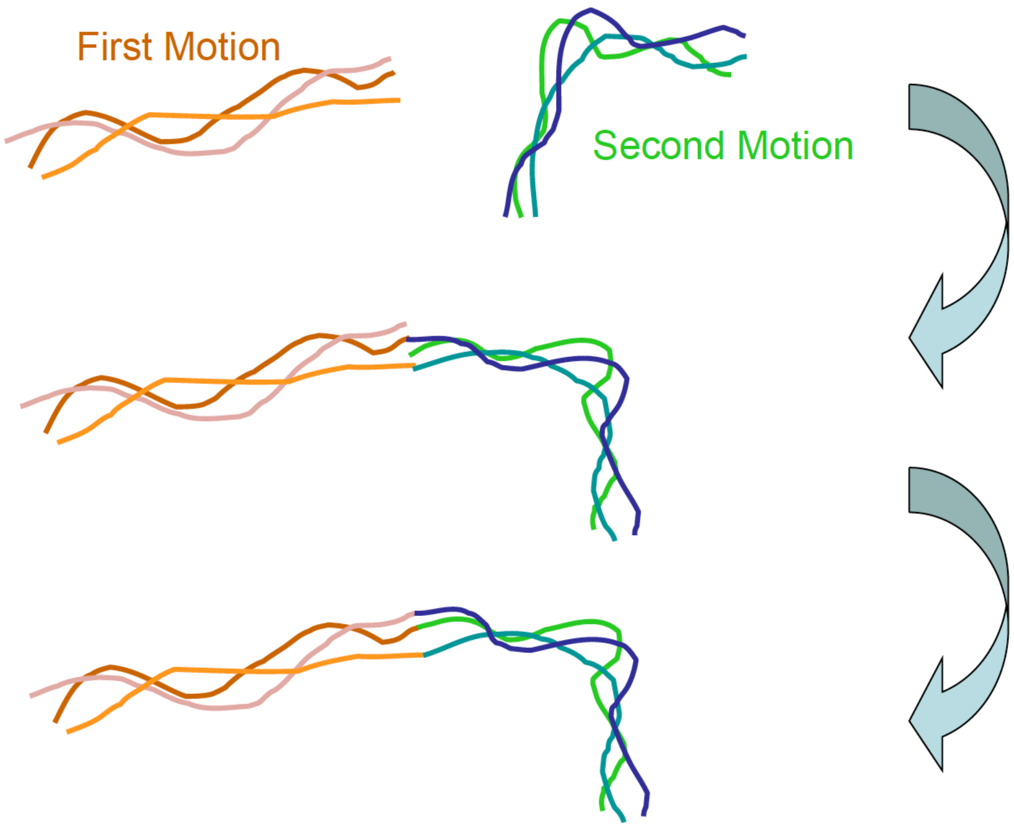
The position of the root segment

The orientation of the root segment

The orientations of body segments w.r.t. their parents (joint angles)

Editing Motion

Connecting Motion Segments



Alignment

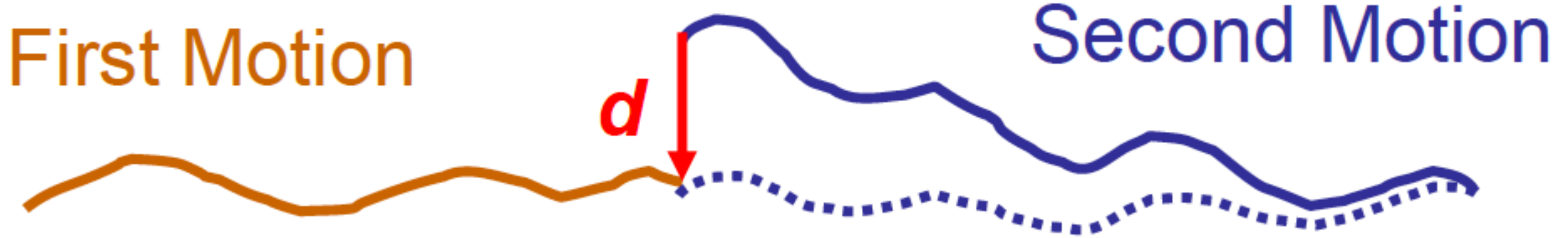
Rotate and translate the second motion to align two motions

Warping

Warp the motions at the boundary so that they can be connected smoothly

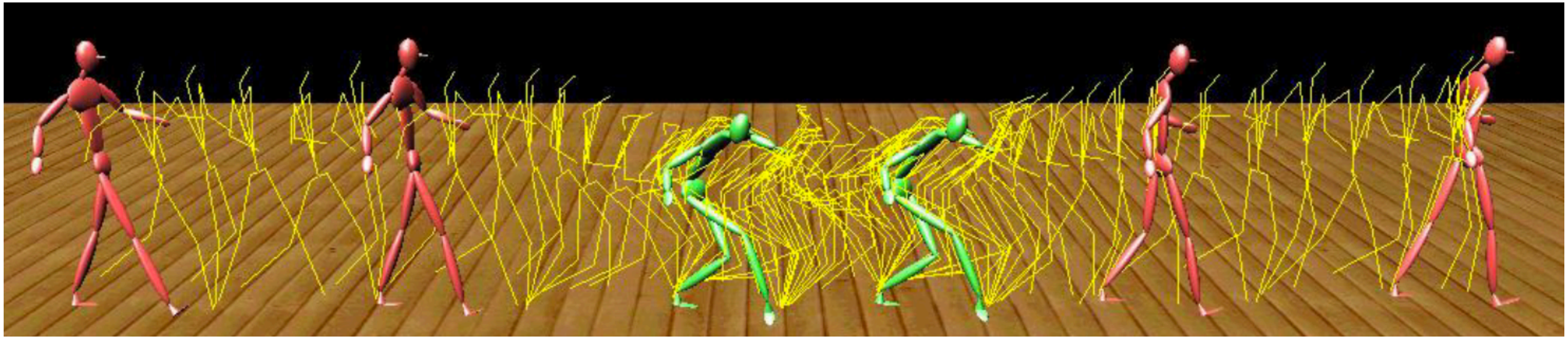
Alignment and Warping

- **Alignment**: The end of the motion A should be aligned to the beginning of the next motion B
- **Warping**: Deform a motion smoothly so that it seamlessly connects to its previous motion



Blending for Smooth Transition

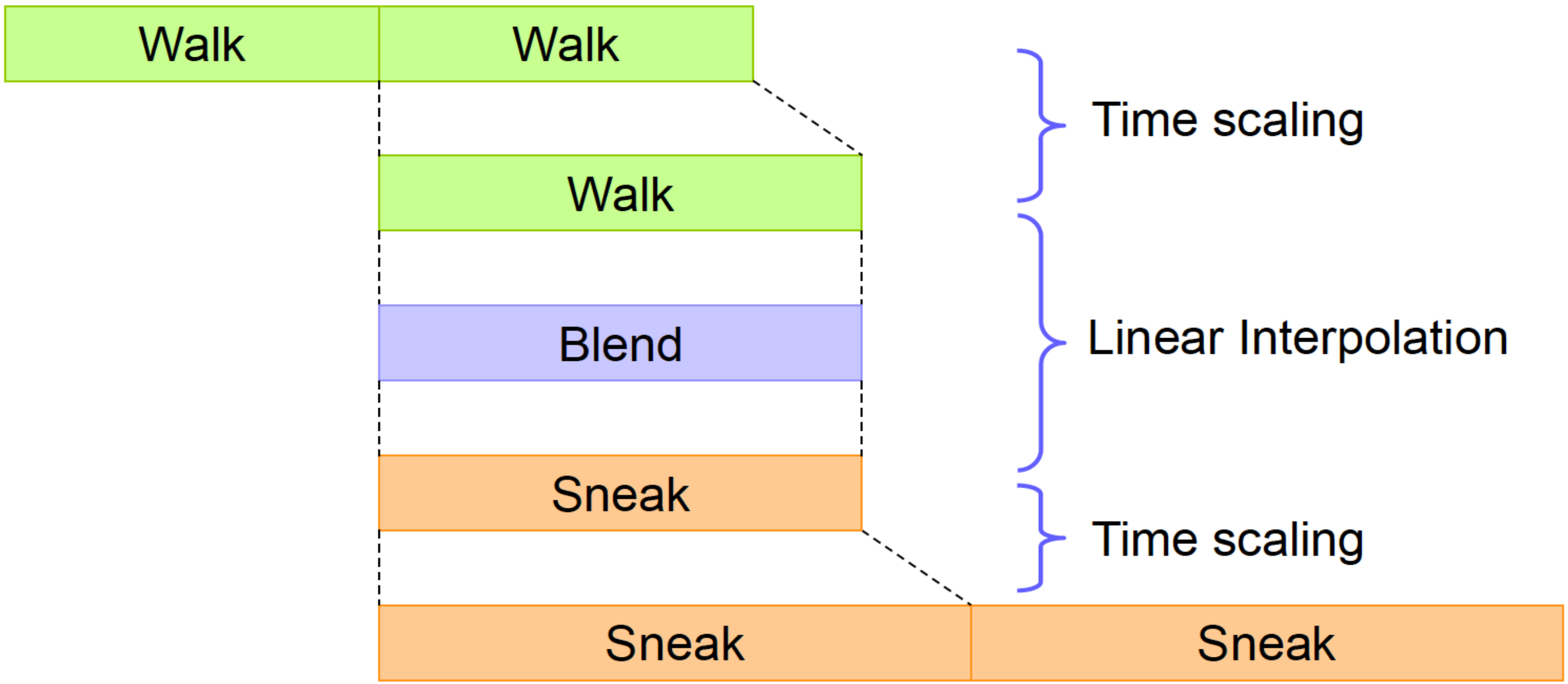
- Case study: walk-to-sneak
  - Transit smoothly over one cycle of locomotion
  - “Walk” is faster than “sneak”
  - One cycle of “sneak” is longer than one cycle of “walk”



Jehee Lee and Sung Yong Shin, A Hierarchical Approach to Interactive Motion Editing for Human-like Characters, SIGGRAPH 99

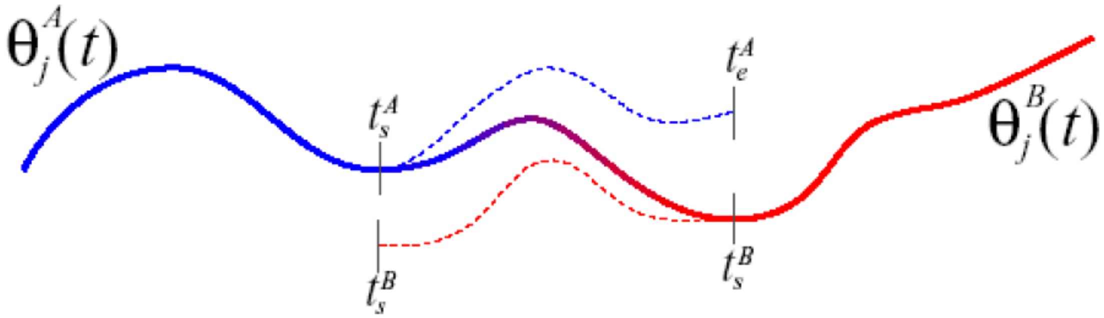
Blending for Smooth Transition

- Blend over the overlapping time interval



Blending for Smooth Transition

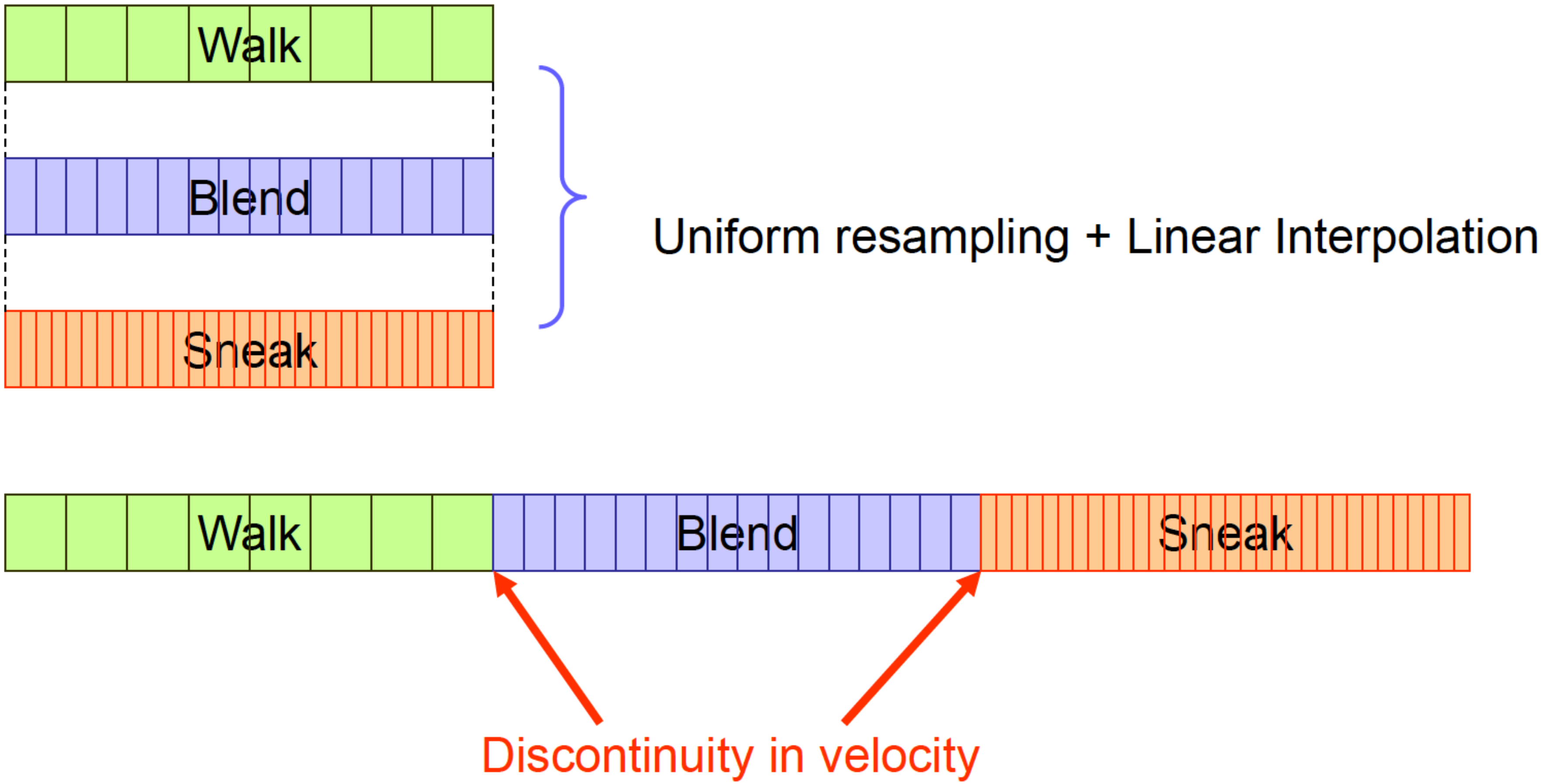
- Linear interpolation between motions
  - Slerp for orientation components
  - A scalar transition function **s**(t)



$$s(t) = \frac{1}{2}\cos(\frac{\pi}{L}t) + \frac{1}{2}$$

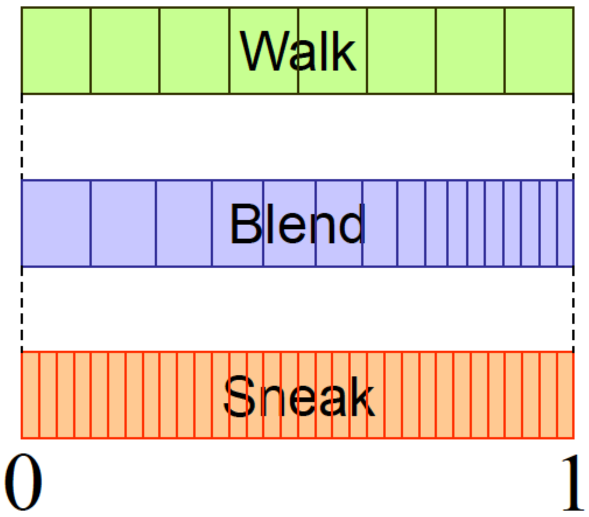
Time Scaling

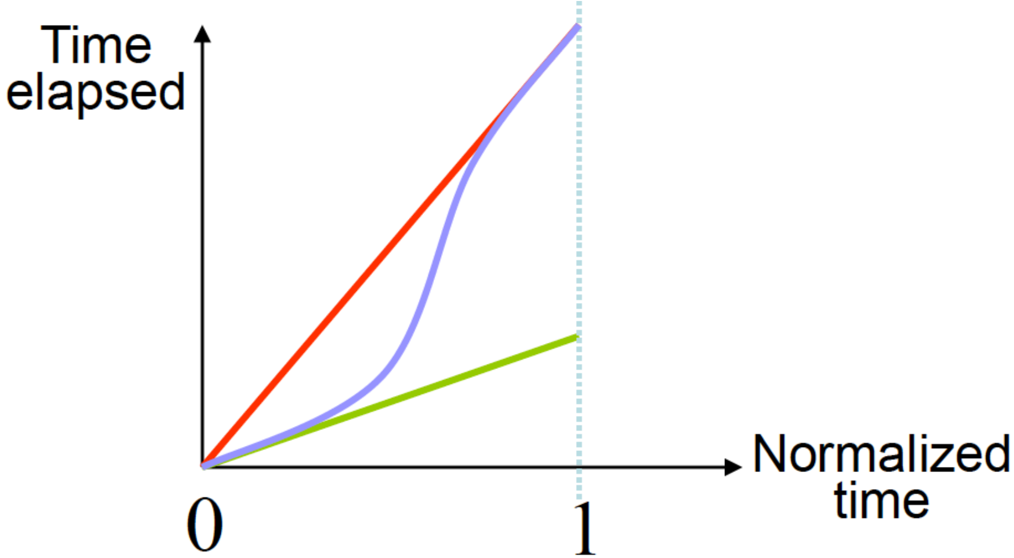
- Discontinuity in velocity



Time Scaling

- Non-uniform resampling

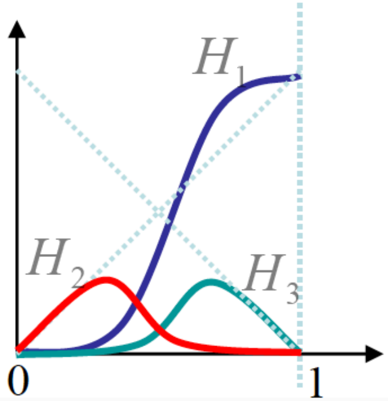




$T(t) = H_1(t) + H_2(t)\, f_1 + H_3(t)\, f_2$

T(0 = 0, T(1) = 1

T’(0) = f_1, T’(1) = f_2



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

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

$$H_3(t) = t^3 - t^2$$

Motion Editing (connecting, blendind, warping, etc.)

- Interests
  - Very easy to program
  - Real-time
  - No need to make new captures

Largely used in animation!

- Disadvantages
  - Interpolate among different styles of gestures: style coherence?
  - Hypothesis that the composition of natural motion produces natural motion-> not true!
  - After spatial and temporal deformation: motion may no longer respect certain motion laws (kinematics, physics,) -> introduce mechanical constraints [Safanova 05].
  - Does not promote interactivity

Motion and Transition Graphs

Motion and Transition Graphs

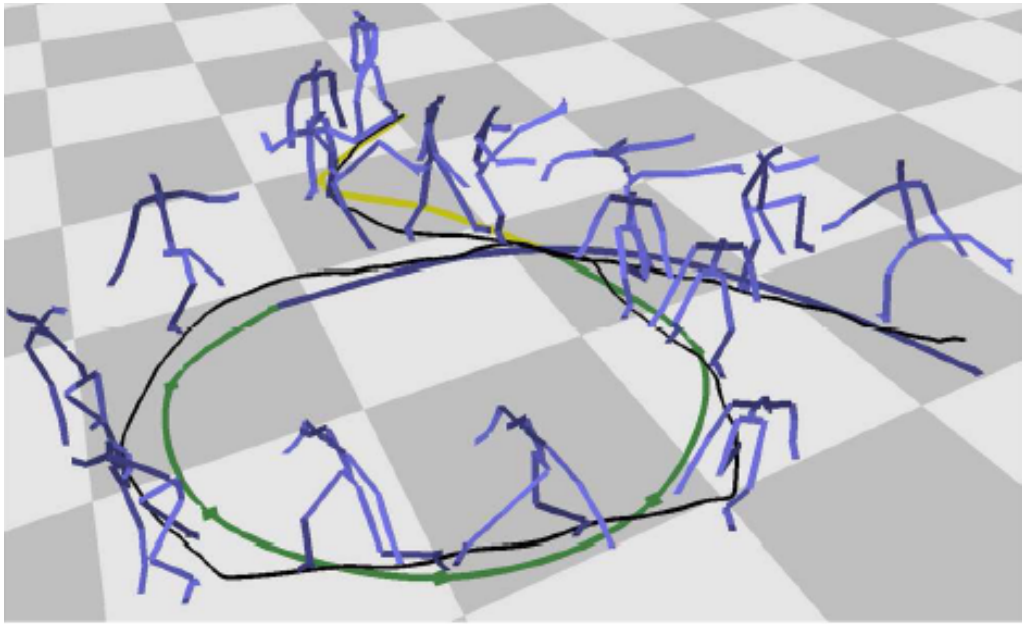
- Motion graphs:
  - the nodes are skeletal poses (postures and velocity)
  - and the arcs of possible transitions between 2 poses [Kovar & Gleicher 02].
- Transition graphs: linked to a notion of distance between poses -> use of the similarity between the angles and articular velocities of the postures [Lee 02], [Wang 03].

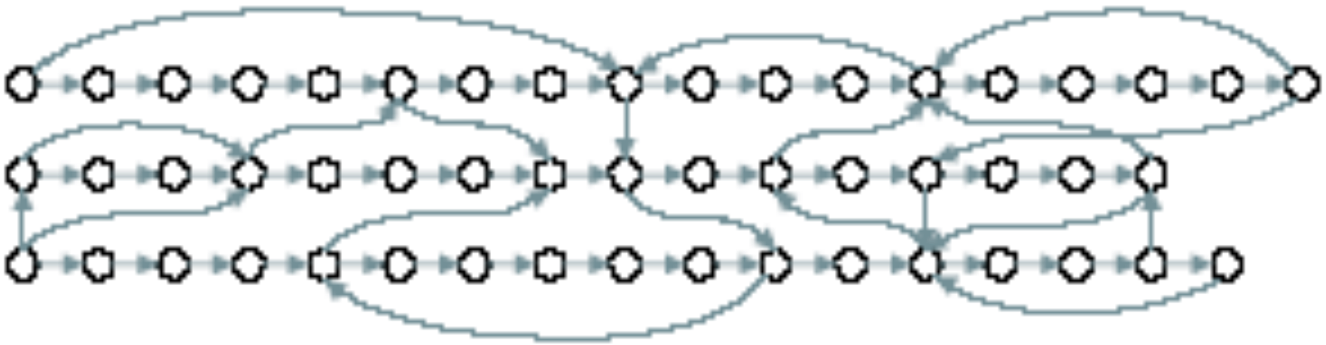
Motion and Transition Graphs

- Arikan 02]: added torso speed and acceleration information
- HMM: Estimation of the probabilities related to the states of transitions on movement, each having their own style (different dance gestures) [Brandt 00]

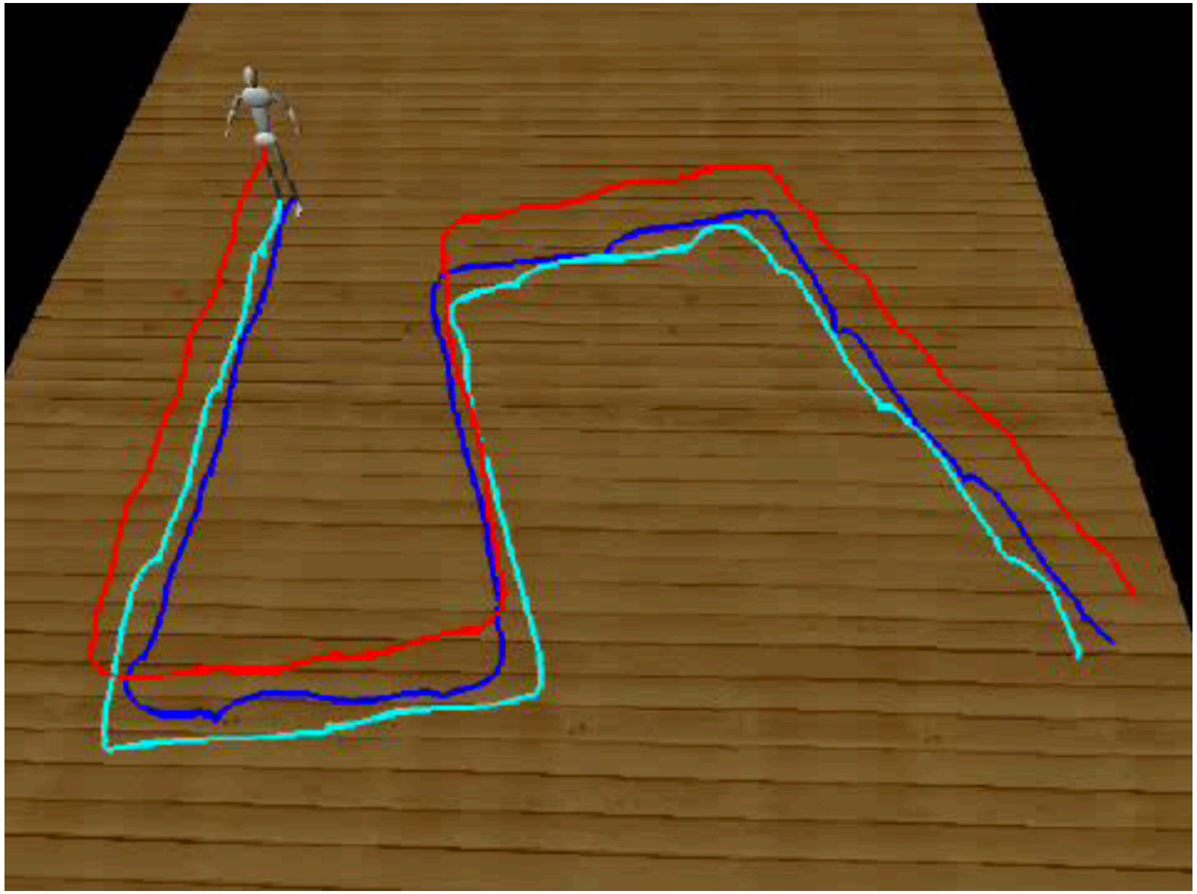
Motion Graphs

- Thanks to a distance computing, it's possible to determine all the possible transitions in the motion graph [Kovar 02]





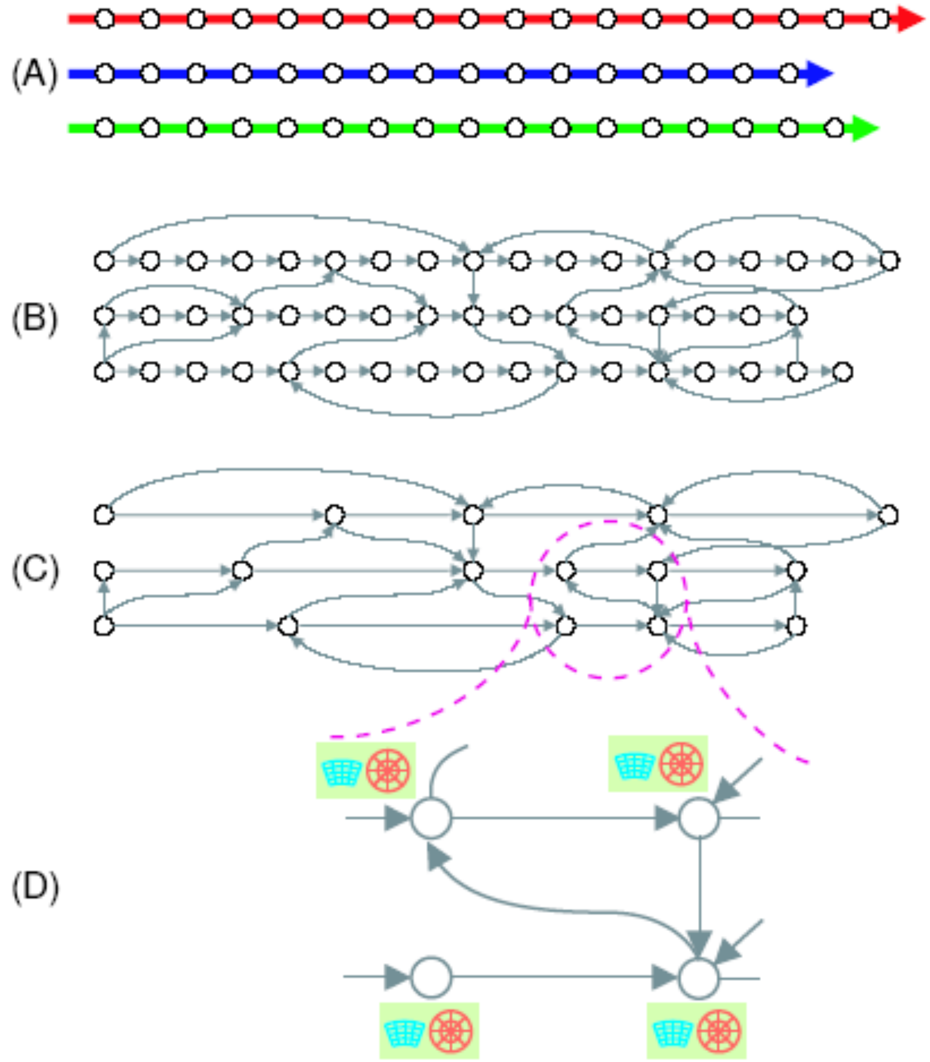
Transition Graphs



Jehee Lee, Jinxiang Chai, Paul Reitsma, Jessica Hodgins, Nancy Pollard, Interactive Control of Avatars Animated with Human Motion Data, SIGGRAPH 2002

Transition Graphs

- Generating a motion in this graph consists in finding a path from one current pose to a desired one [Lee 04]



Motion Graphs

- Lee et al go further: simplification by grouping the nodes that are part of the same motion sequence (those that follow each other)
  - simplified graph: the nodes that remain are key postures of the movement

Motion Graphs: Interests

- Fine user control by defining high-level tasks to be performed in the context of motion graphs
- Interactive, realistic animation

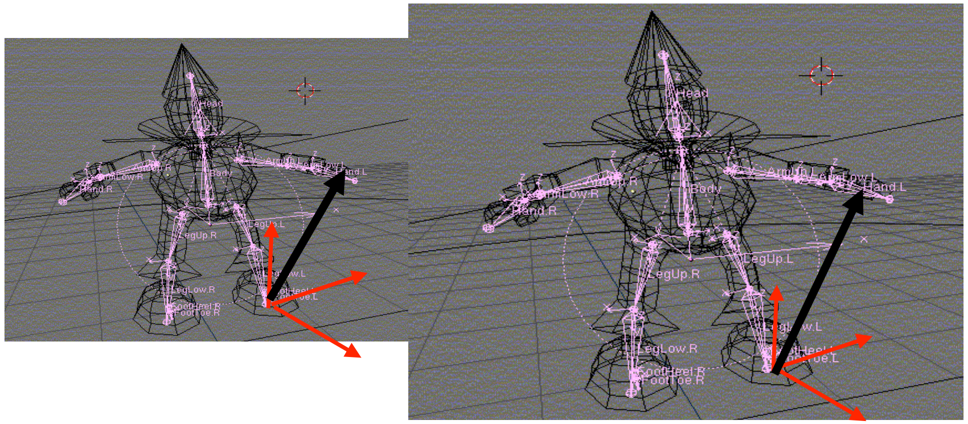
Motion Graphs: Disadvantages

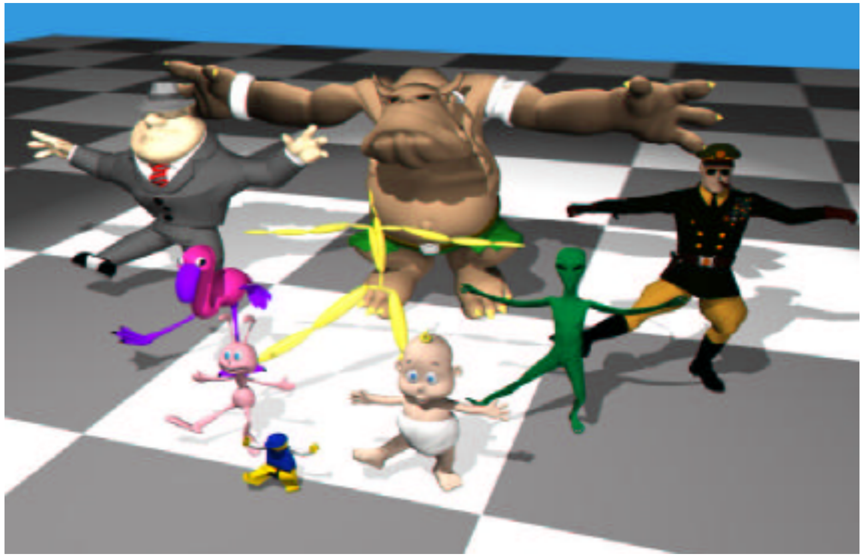
- Requires capturing a large volume of motions to sample the task space as finely as possible.
- Moreover, if a movement is added to the database, it is necessary to recalculate everything because transitions can be questioned.

Motion Retargeting

Motion Retargeting

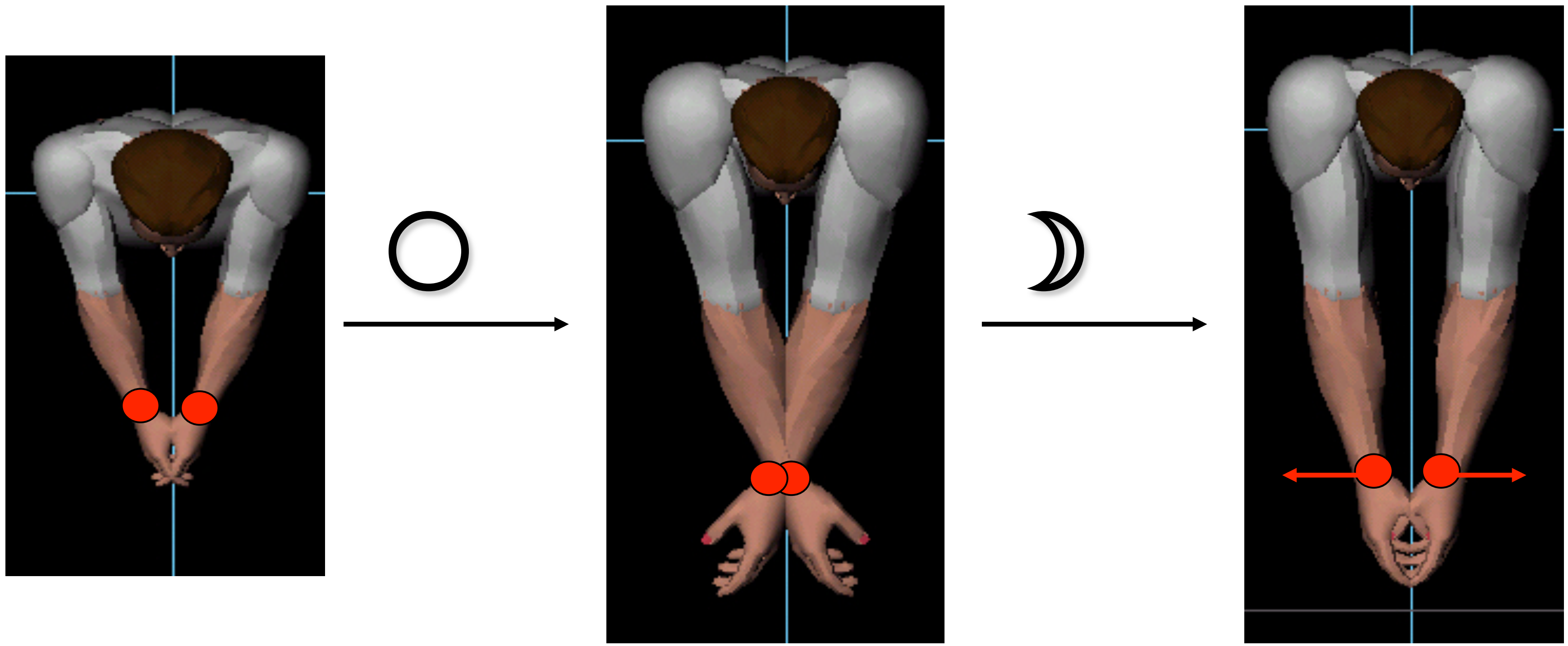
- Different morphologies: different segemnt sizes between the real actor on which the motion was captured and the synthetic skeleton





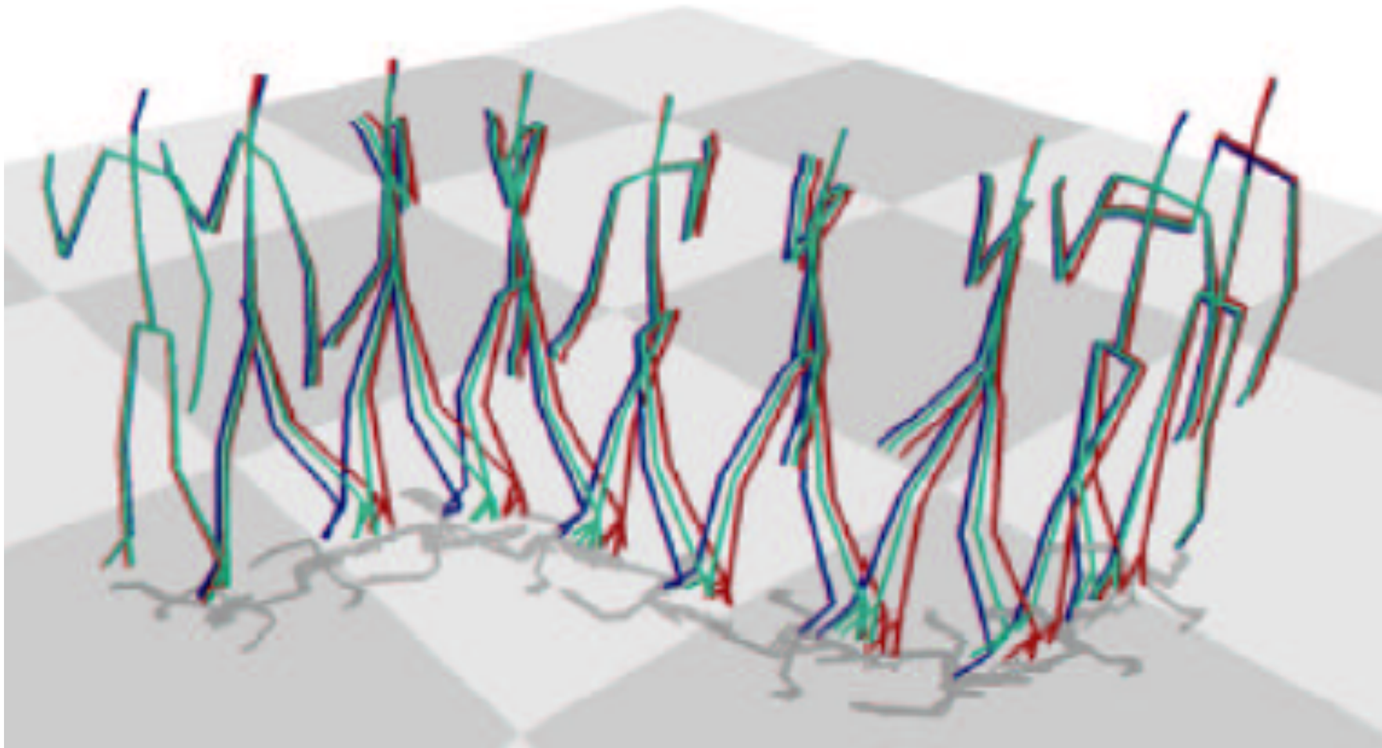
Motion Retargeting

- One solution
  - Global « Scaling »: exact duplication of the angles
  - But different proportions between the segments! (male, female, child)



Motion Retargeting

- In addition to skeletal constraints, there may be environmental constraints.
  - e.g.: footprints, objects to catch, different step sizes in stairs, …



Motion Retargeting

- Compromise between
  - preserving angles (postures)
  - Preserving position constraints
    - hands over a table
    - feet that won't go into the ground if you replace a flat floor with a bumpy one