Snap-Together Motion

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CS676 : Computer Vision

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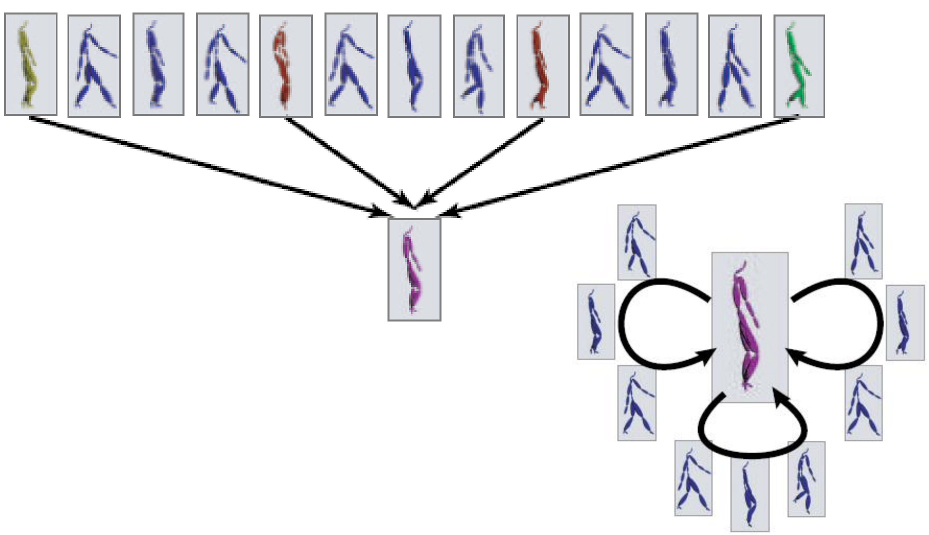
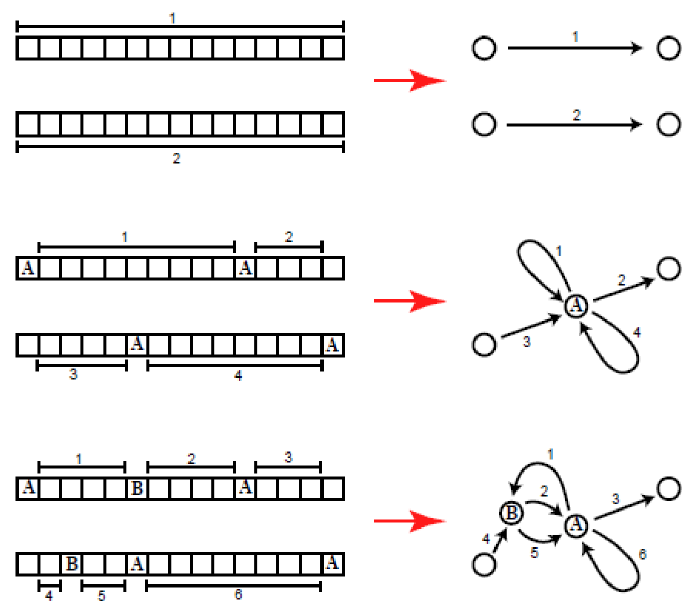
Overview

- What?
  - simple graph structure that facilitates efficient planning of character motions
  - responsive, controllable, and efficient to simulate.
- Why?
  - Entertainment
    - virtual worlds with believable synthetic characters and realistic motion
    - Interactive gaming
    - 3D Animation
  - Understanding basic structure in human motion
- Some traditional practices and their problems
  - Move Trees
    - Fully authored graph structures lack high connectivity
  - Selective corpus
  - No automation
  - No cut-transitions
  - Visual artifacts

Pipeline

- Corpus
  - Motion capture data in standard skeletal format
  - Each frame: $(\mathbf{p}, \mathbf{q}_1, \ldots, \mathbf{q}_n, \mathbf{o}_1, \ldots, \mathbf{o}_n)$. $\mathbf{p}$ – root joint, $\mathbf{q}$ – orientation, $\mathbf{o}$ – offset.
  - Foot plant constraints.
- Graph
  - Edges - > clips and nodes -> common pose for a 'match set'
  - Automated and interactive
- Transitions
  - Replacing the match set with a rigid transformation of common pose
  - C_1 continuity for seamless cut-transitions.

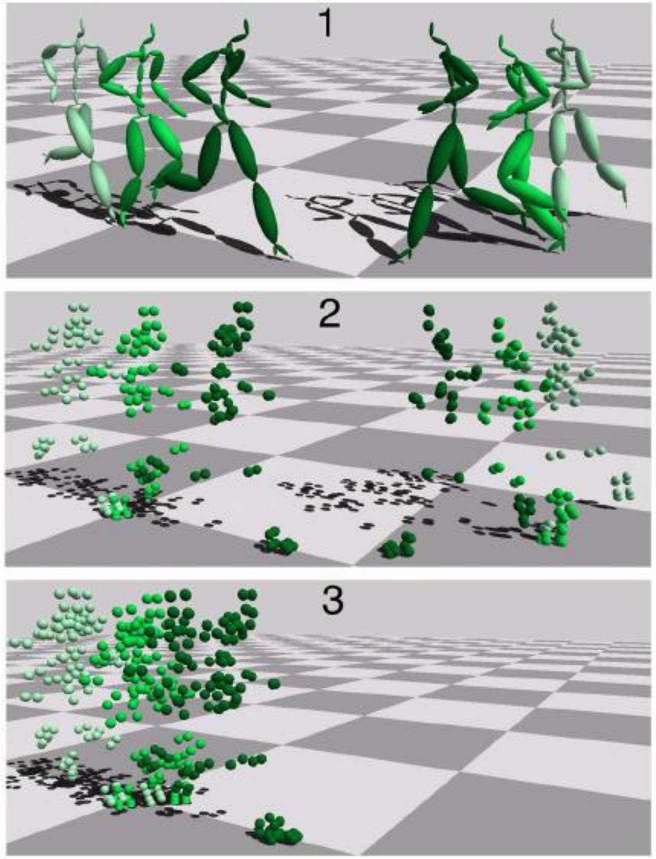




Choosing Match Frames

- Finding collection of "similar" frames from the corpus.
  - Similarity based on distance metric $D(\mathbf{F_i}, \mathbf{F_j})$
  - Small neighborhood of frames around each frame and Cloud of points.
  - Common coordinate system.
  - Computing optimal weighted sum of squared differences.

$$D(\mathbf{F_i}, \mathbf{F_j}) = \min_{\theta, x_0, z_0} \sum_k w_k \|\mathbf{p_{i,k}} - \mathbf{T}_{\theta, \mathbf{x_0}, \mathbf{z_0}} \mathbf{p_{j,k}}\|^2$$



  - Closed form solution:

$$\theta = \arctan \frac{\sum_i w_i (x_i z_i' - x_i' z_i) - (\overline{x}\overline{z'} - \overline{x'}\overline{z})}{\sum_i w_i (x_i x_i' + z_i z_i') - (\overline{x}\overline{x'} + \overline{z}\overline{z'})}$$

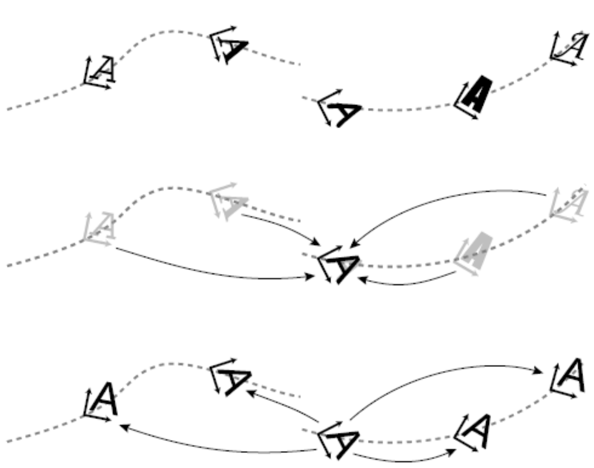
$$x_0 = (\overline{x} - \overline{x'} \cos(\theta) - \overline{z'} \sin \theta)$$

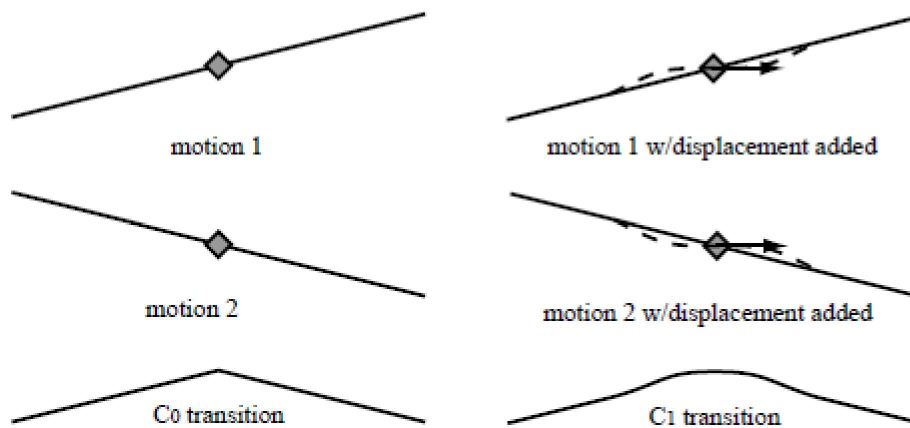
$$z_0 = (\overline{z} + \overline{x'} \sin(\theta) - \overline{z'} \cos \theta),$$

  - Given $\mathbf{F}$, local minimas of $D(\mathbf{F}, \mathbf{F_i})$, $\mathbf{F_i} \in \mathbf{M_k}$ lying below a threshold are computed $\forall$ $\mathbf{M_k}$ in the corpus to form a match set $S = \{\mathbf{F_1}, \mathbf{F_2}, ..\}$

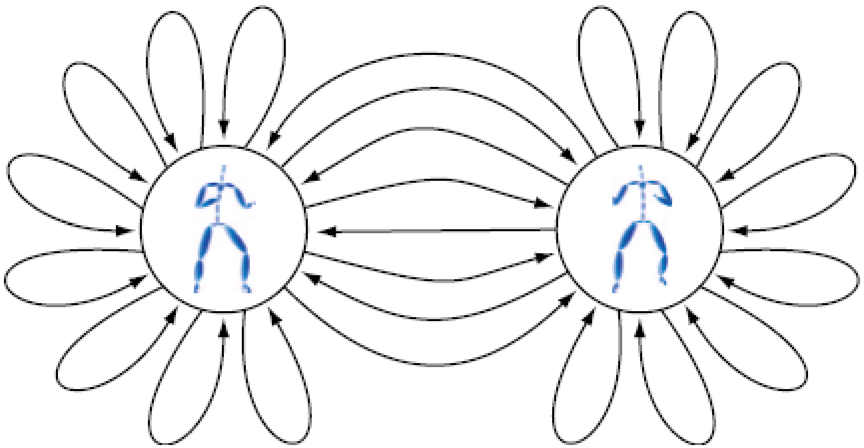
Transitions

- Transitions without constraints
  - Common pose $\mathbf{F}_{S_i}$ is calculated by averaging over match frames
  - Using pair-wise transformations $\mathbf{T}_{p,q}$ (aligns $\mathbf{F}_p$ to $\mathbf{F}_q$) is inconsistent since,
    $\mathbf{T}_{p,q} \times \mathbf{T}_{q,r} \neq \mathbf{T}_{p,r}$
  - A common frame $\mathbf{F}_{base}$ is chosen and $\mathbf{T}_{p,q}$ is defined as $\mathbf{T}_{p,base} \times (\mathbf{T}_{q,base})^{-1}$
  - Closest to the rest of the frames is chosen as base frame.
  - The root position, joint offsets, and joint orientations of $\mathbf{F}_{S_i}$ are the average of the corresponding quantities in the match frames.
  - Replacing each $\mathbf{F}_k \in S_i$ by $(\mathbf{T}_{k,base})^{-1} \times \mathbf{F}_{S_i}$ assures C_0 continuity.
  - Displacement mapping on velocities results in C_1 continuity.
  - Displacement maps generally result in constraint violation





Results



STM overview:

http://www.youtube.com/watch?v=ls_qdjyOFzE&feature=youtu.be

Questions???