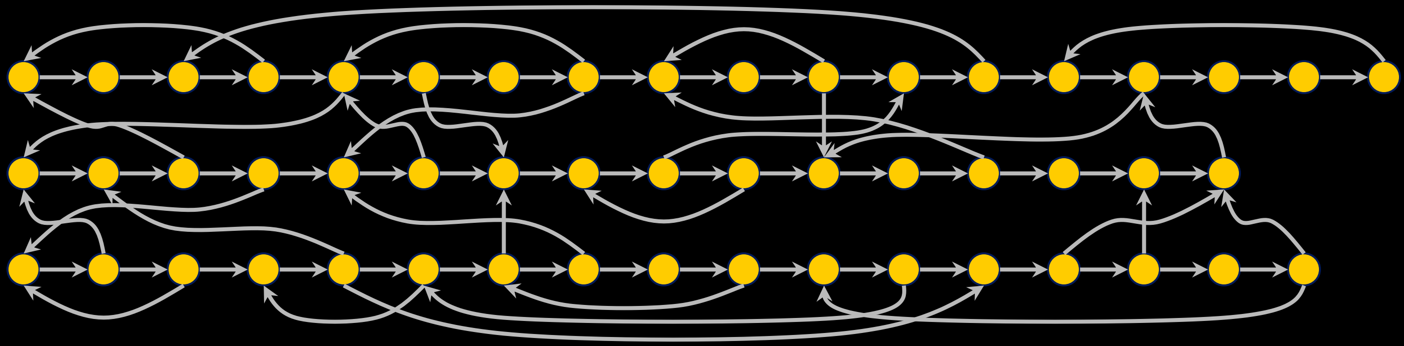
Motion Graph—Video Textures



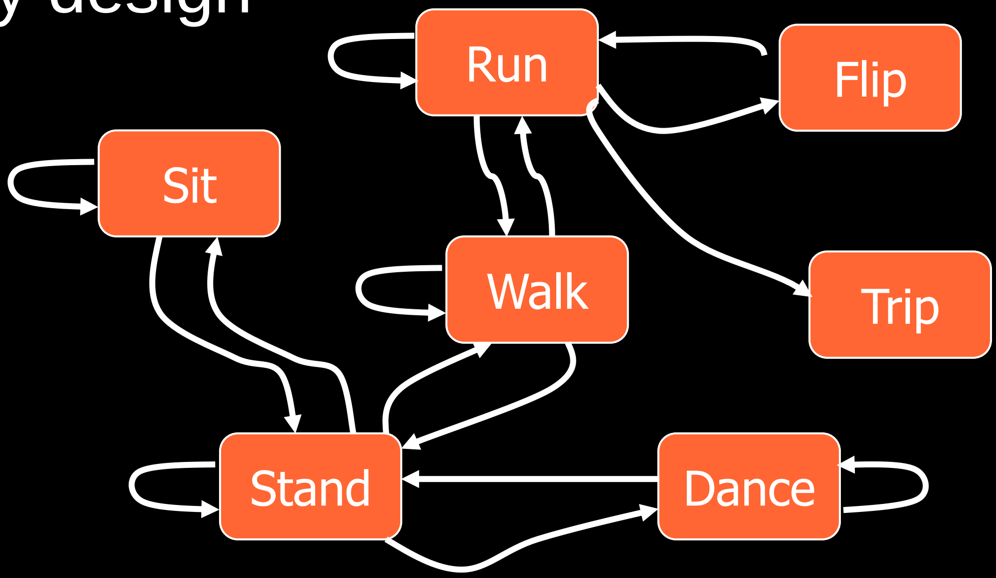
Slides and videos from
http://cpl.cc.gatech.edu/projects/videotexture/SIGGRAPH2000

Motion Synthesis from Examples

- High Quality, Expressive Motion
  - Need motion capture (examples)
- Flexible, long-running, controllable
  - Need synthesis
- Synthesis from Examples!

Motion Graph

- Hand build motion graphs in games
  - Many short, carefully planned, labeled motion clips
  - Significant amount of work required
  - Limited transitions by design



Motion Graph (cont.)

- Motion graphs can also be built automatically
  - Unlabelled motion database
  - Continuous, long sequence

Inspiration from Video Textures

- Schödl et al., “Video Textures”, SIGGRAPH’00

video clip

video texture

Slides and videos from
http://cpl.cc.gatech.edu/projects/videotexture/SIGGRAPH2000

Video Textures

How do we find good transitions?

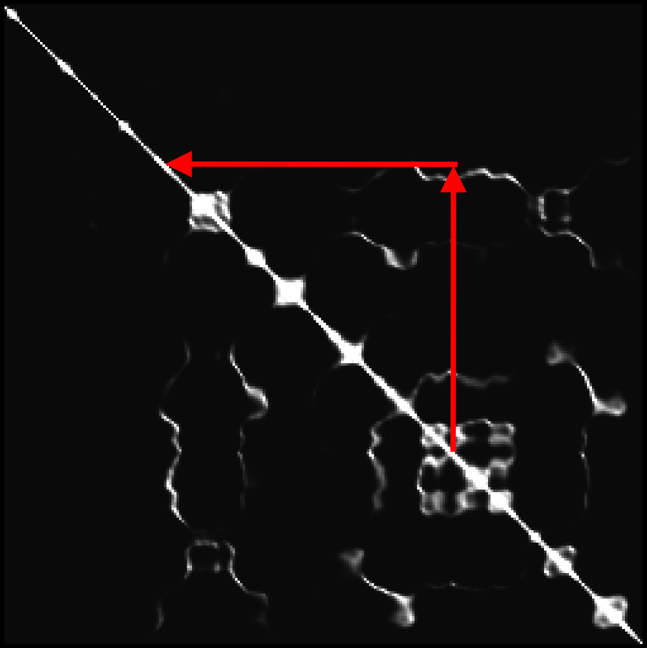
Finding good transitions

- Compute L_2 distance $D_{i,j}$ between all frames

vs.

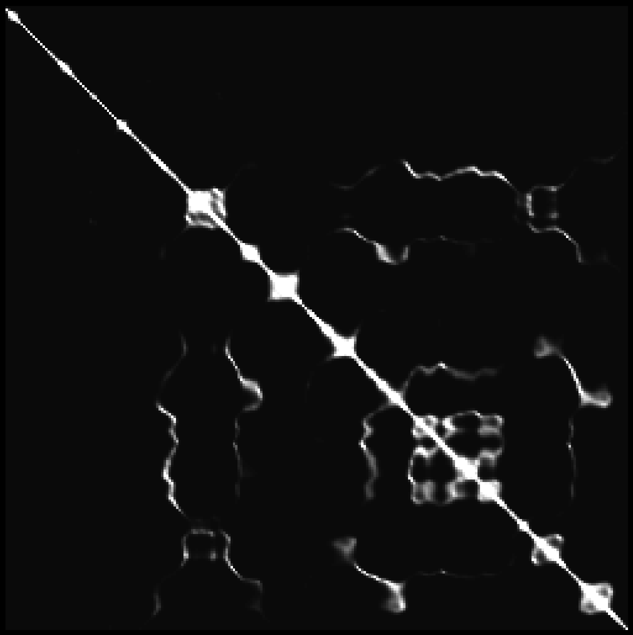
frame *i*

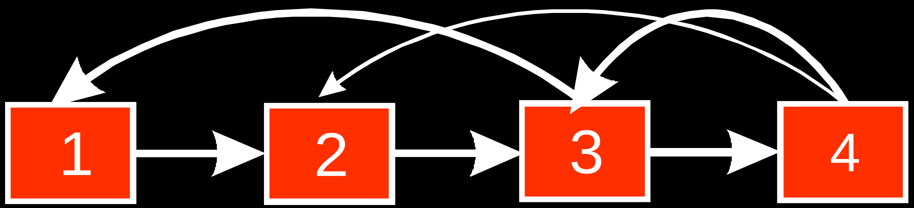
frame *j*



- Similar frames make good transitions

Markov Chain Representation



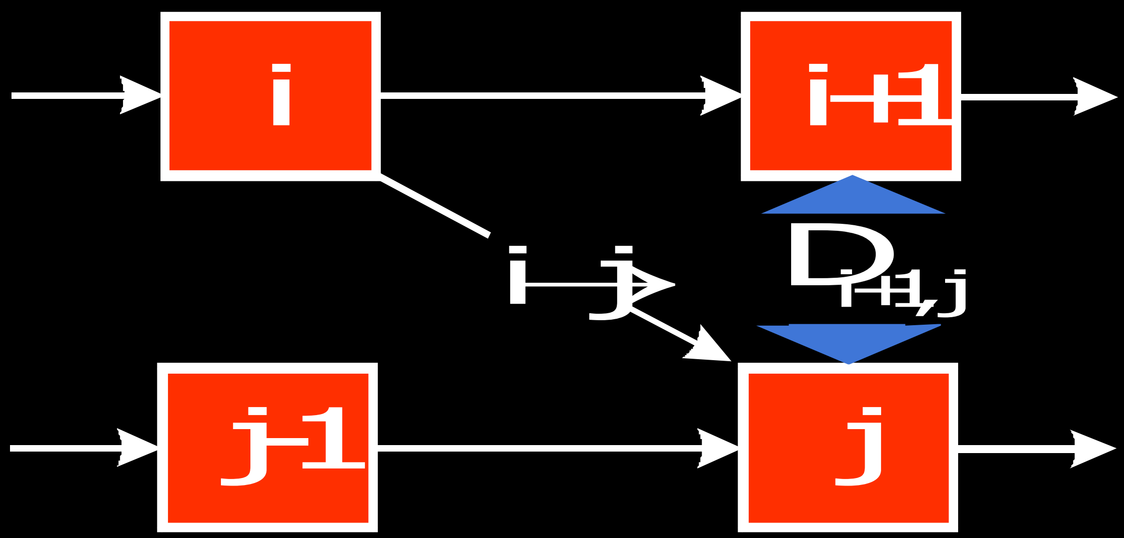


Similar frames make good transitions

Transition Costs

- Transition from i to j
  if successor of i is similar to j

Cost function: $C_{i \to j} = D_{i+1,\, j}$



Transition Probabilities

- Probability for transition $P_{i \to j}$ inversely related to cost

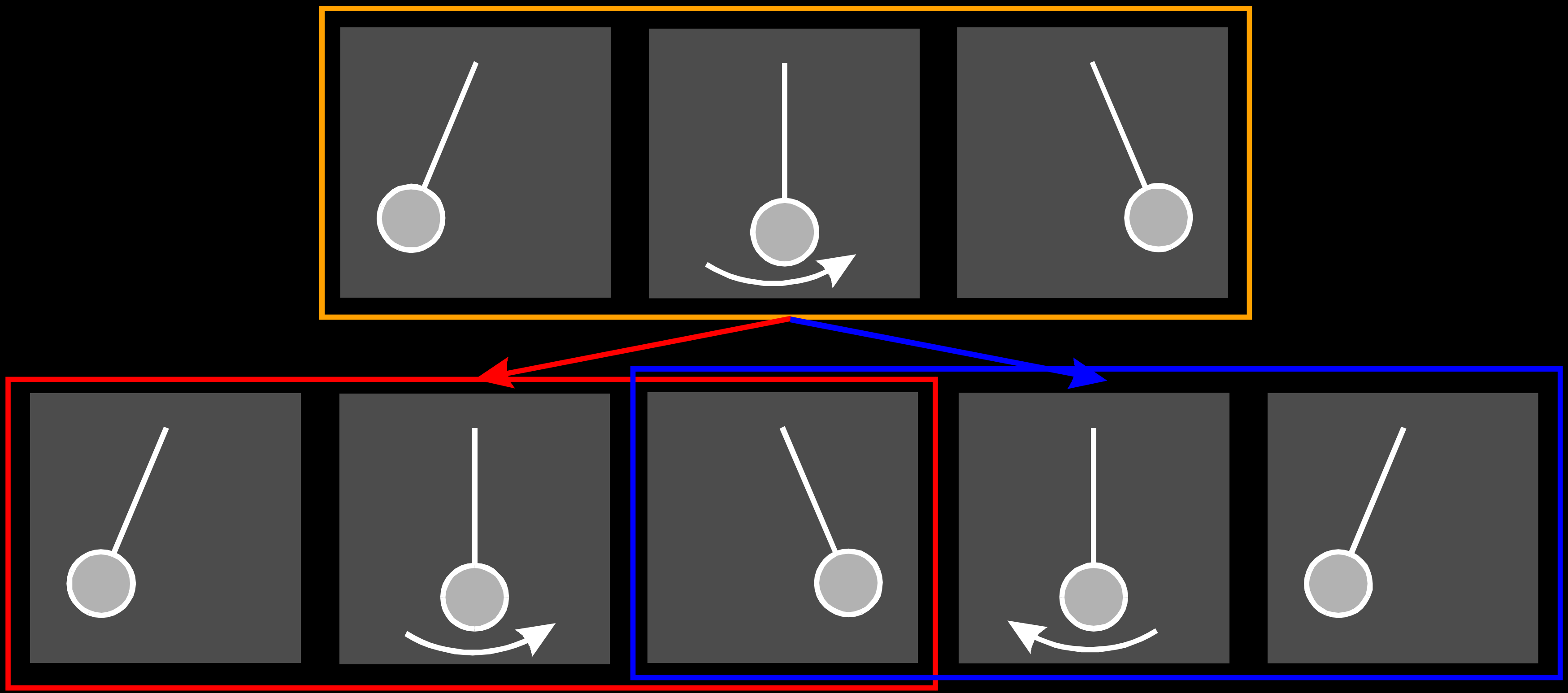
$$P_{i \to j} \sim \exp\left(- C_{i \to j} / \sigma^2 \right)$$

high σ

low σ

Preserving Dynamics

Preserving Dynamics



Preserving Dynamics

- Cos

$$C_{i \to j} = \sum_{k=-N}^{N} W_k D_{i+k+1,\, j+k}$$

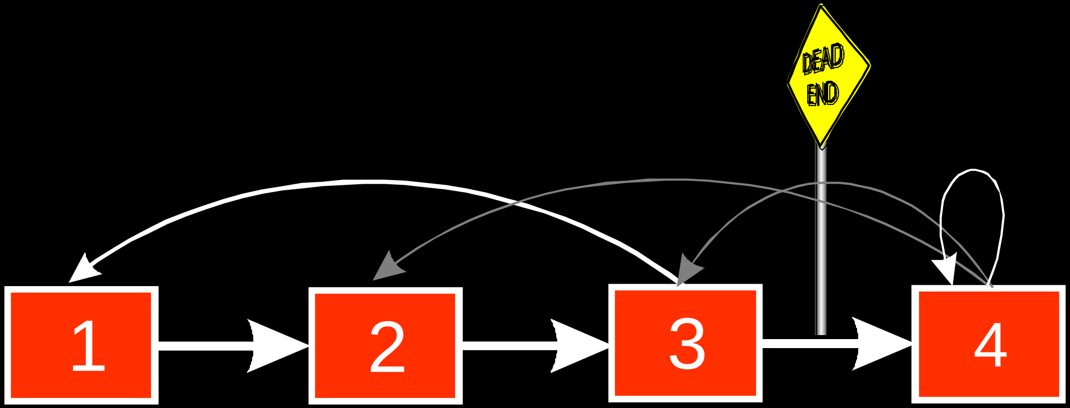
Preserving Dynamics—effect

- Cost for transition *i*→*j*

$$C_{i\to j} = \sum_{k=-N}^{N} W_k D_{i+k+1,\, j+k}$$

Dead Ends

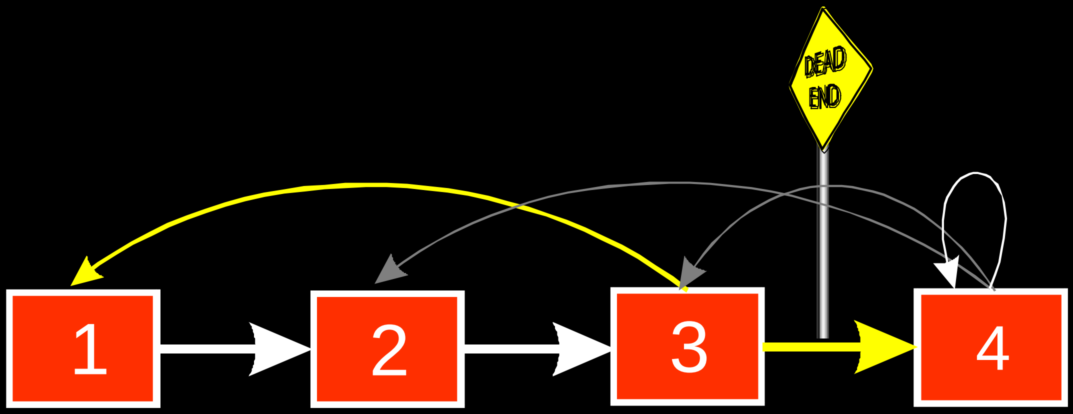
- No good transition at the end of sequence



Future Cost

- Propagate future transition costs backward
- Iteratively compute new cost

$$F_{i \to j} = C_{i \to j} + \alpha \min_k F_{j \to k}$$



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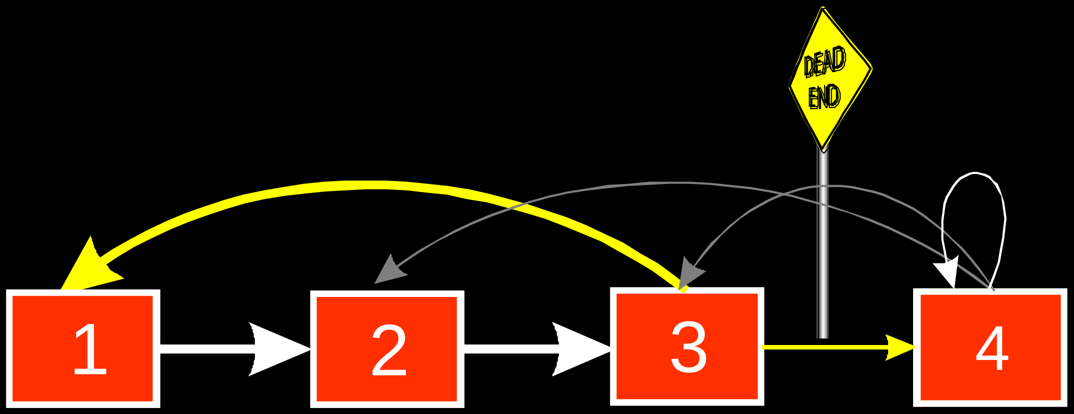


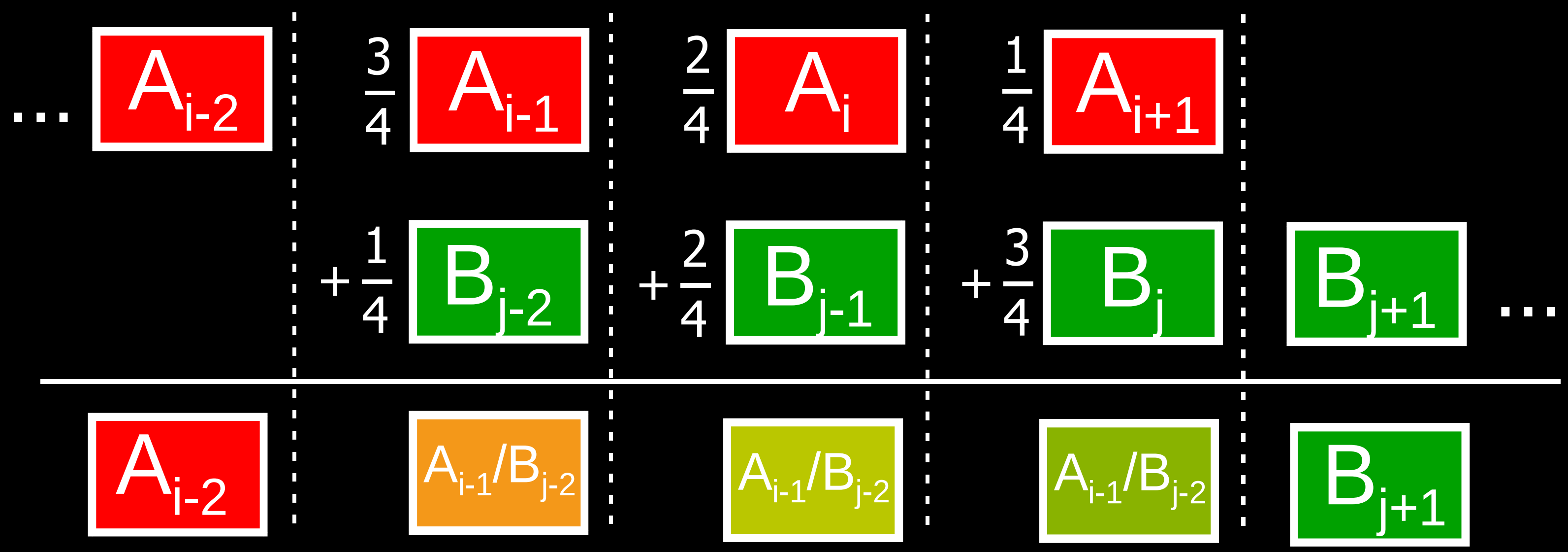
Future Cost—effect

Visual Discontinuities

- Lowest transition cost doesn’t guarantee no discontinuities
- Blending frames at transition is needed
- This is even more important for motion data!

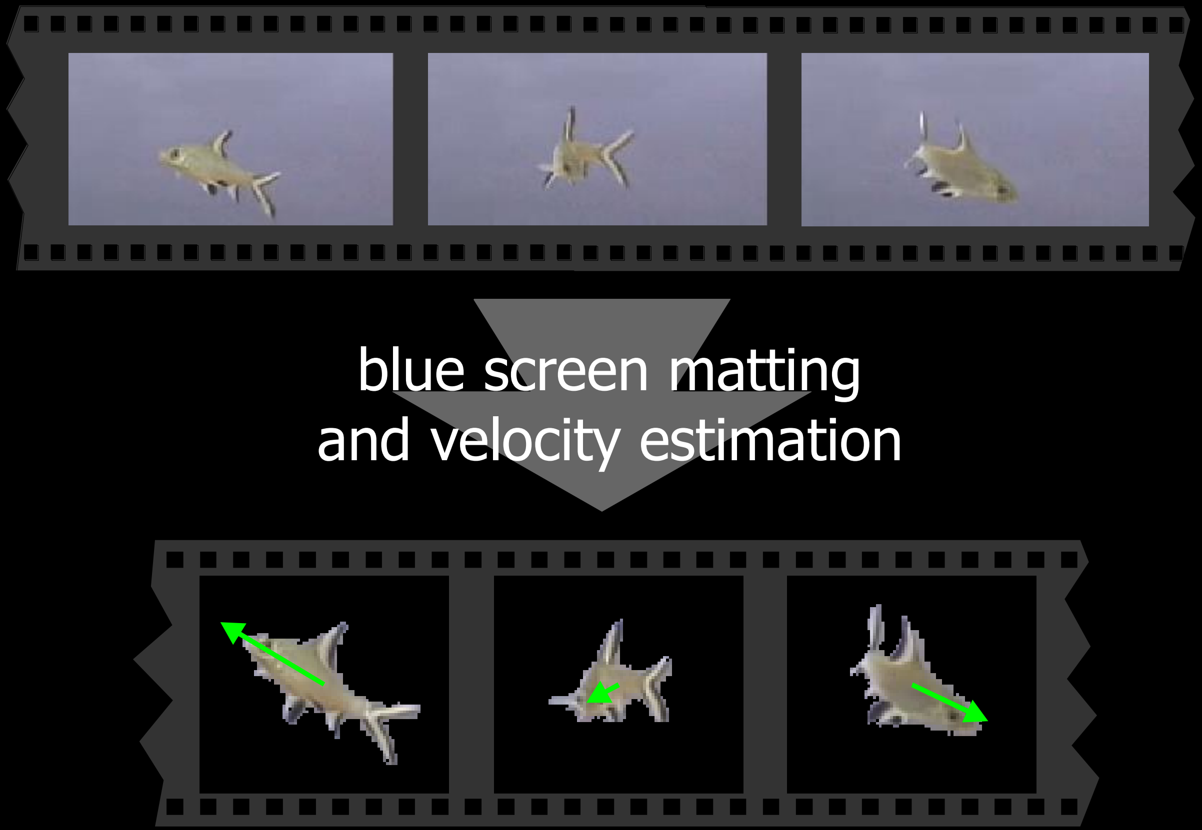
Blending at Transition

- C(t) = w(t)A(t) + (1-w(t)) B(t), t=i-M, ..., i+M



Beyond Random Walk

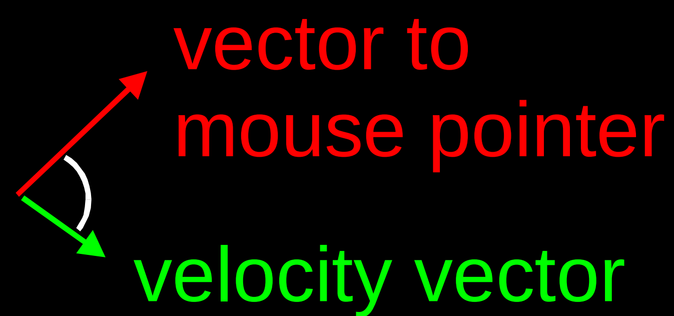
- Interactive control



Adding Control

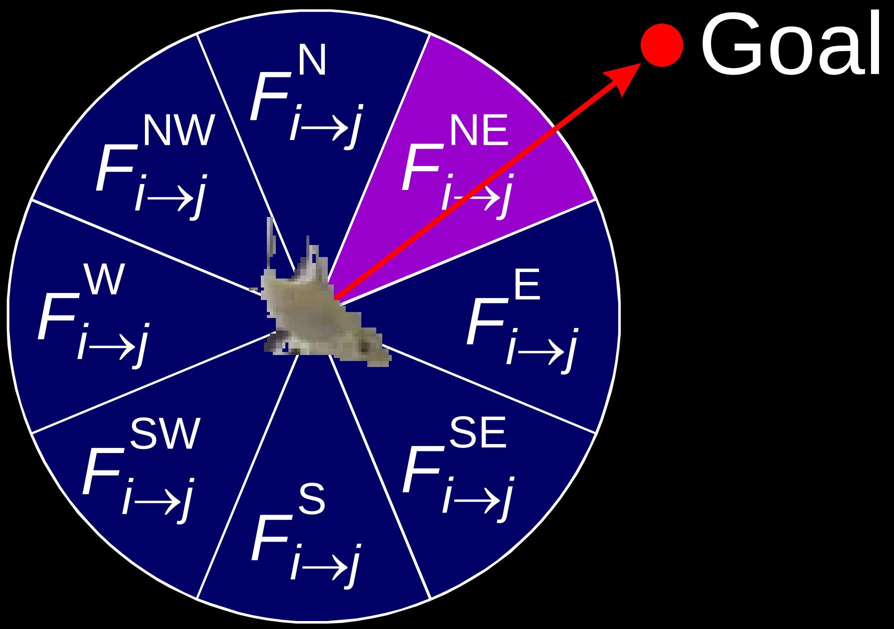
- Augmented transition cost

$$C^{\text{Animation}}_{i\to j} = \underbrace{\alpha\, C_{i\to j}}_{\text{Similarity term}} + \underbrace{\beta\ \text{angle}}_{\text{Control term}}$$



Adding Control

- Need future cost computation
- Precompute future costs for a few angles.
- Switch between precomputed angles according to user input



Interactive Fish

More Fish

Controlled Animation of Video Sprites
Schödl and Essa, SCA'02

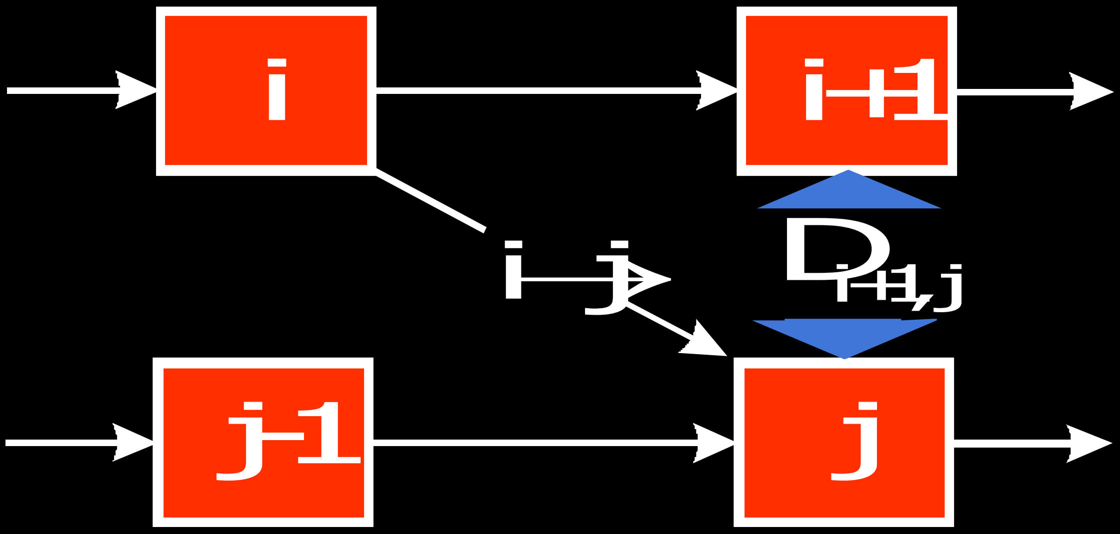
Apply “video textures” to mocap data

- SIGGRAPH’02
  - Li et al., “Motion Textures”
  - Kovar & Gleicher, “Motion Graphs”
  - Arkan & Forsyth, “Interactive Motion Generation from Examples”
  - Lee et al., “Interactive Control of Avatars Animated with Human Motion Data”
  - Pullen & Bregler, “Motion Capture Assisted Animation: Texturing and Synthesis”

Transition Costs

pose difference

Cost function: $C_{i \to j} = D_{i+1,\, j}$



Pose Difference

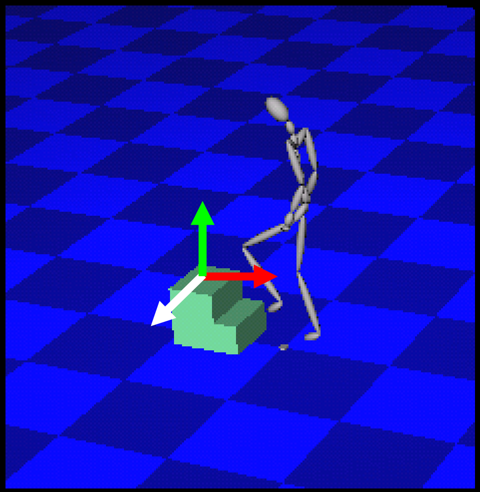
- Various definitions
  - weighted joint angle and velocity difference
    - Lee et al.
  - weighted joint position and velocities in root coord.
    - Arikan & Forsyth
  - weighted point clouds difference (simplified mesh)
    - Kovar & Gleicher

Pose Difference at Root Joint

Global, fixed,

object-relative

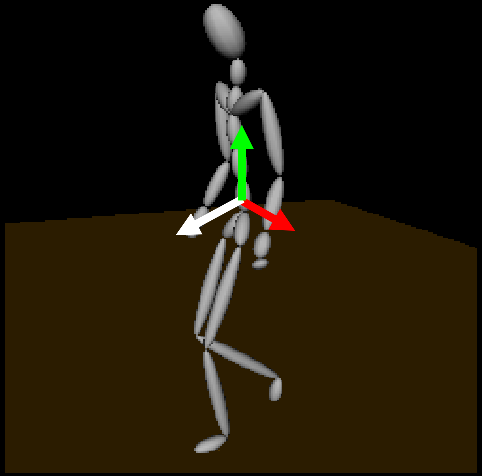
coordinates



Local, moving,

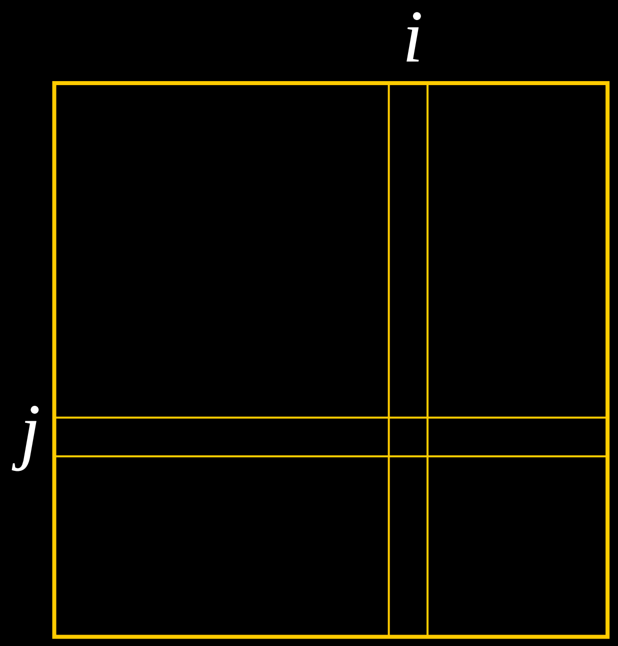
body-relative

coordinates



Pruning Transitions

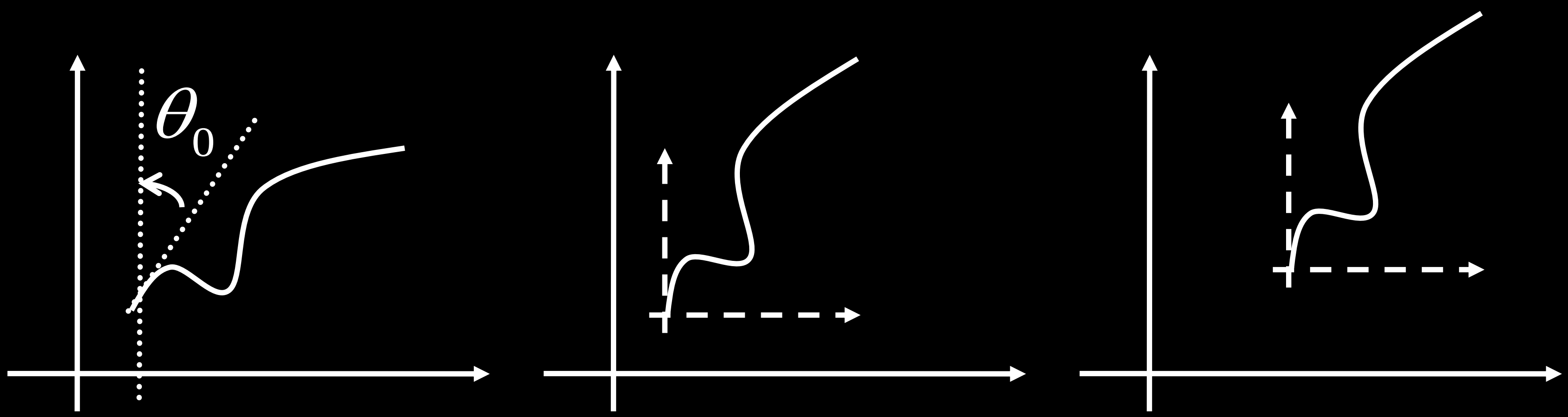
- Reduce storage space
  - Graph is usually represented as a matrix
  - O(n^2) will be prohibitive
- Better quality
  - Pruning “bad” transitions
- Efficient search
  - Sparse graph



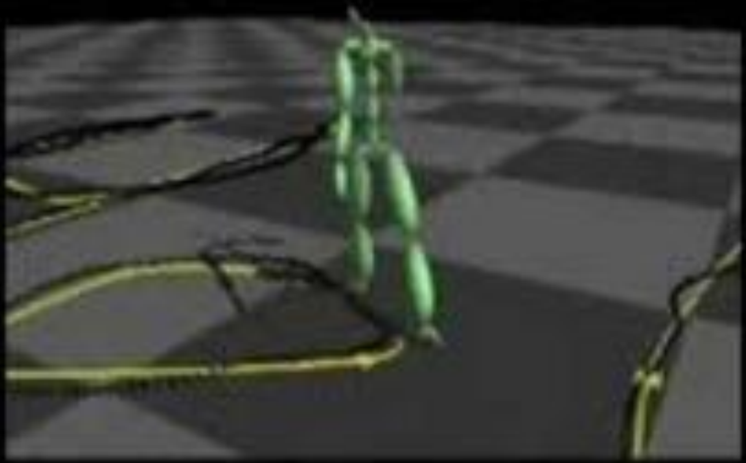
Pruning Transitions

- Contact state:
  Avoid transition to dissimilar contact state
- Likelihood:
  User-specified threshold
- Similarity:
  Local maxima
- Avoid dead-ends:
  Strongly connected components

Aligning Root Joints at Transition



Motion Graphs
Kovar and Gleicher, SIGGRAPH'02



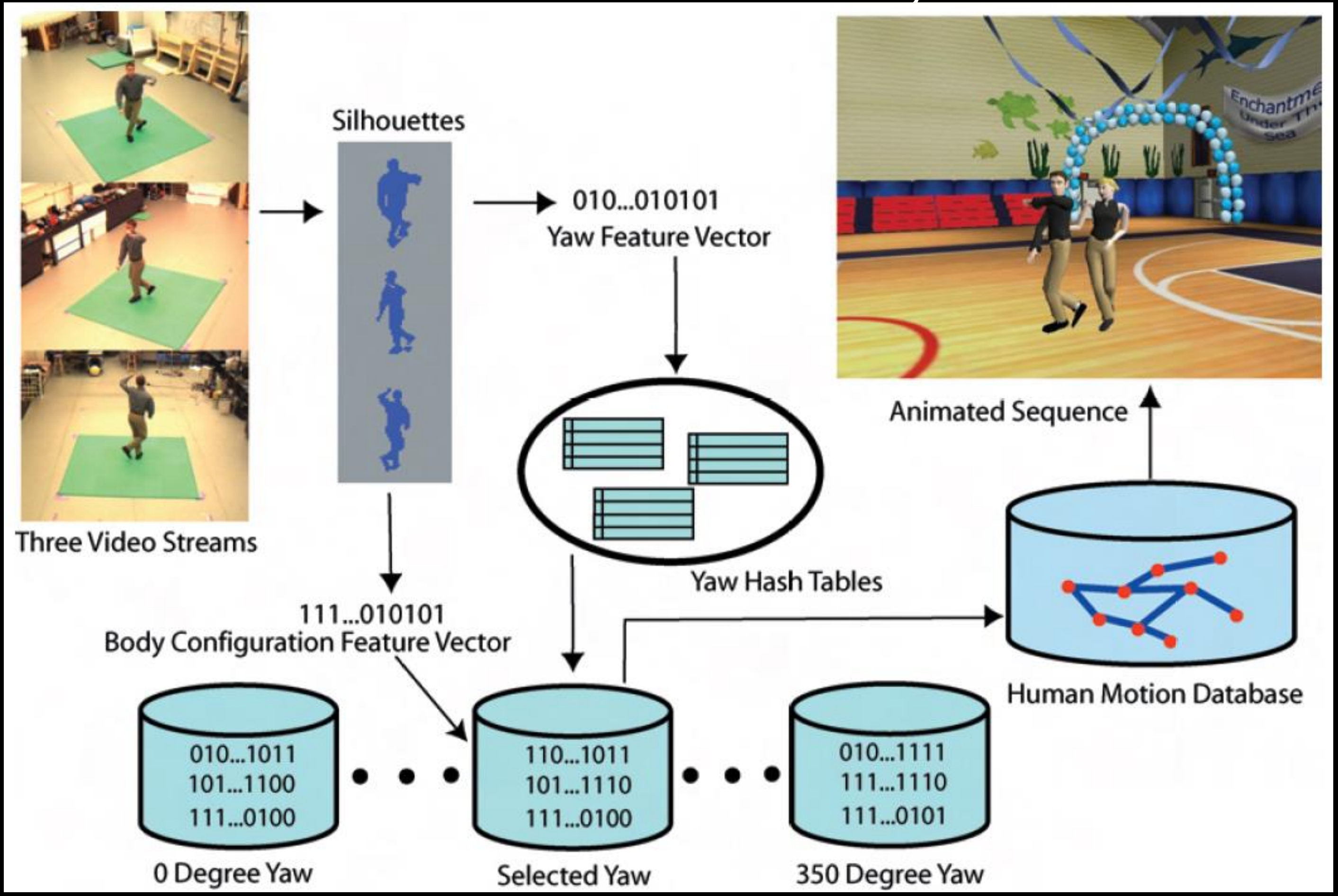
Interactive Avatar Control

Lee, Chai, Reitsma, Hodgins, Pollard, SIGGRAPH'02

- Sketch interface

Application: Video-based Animation

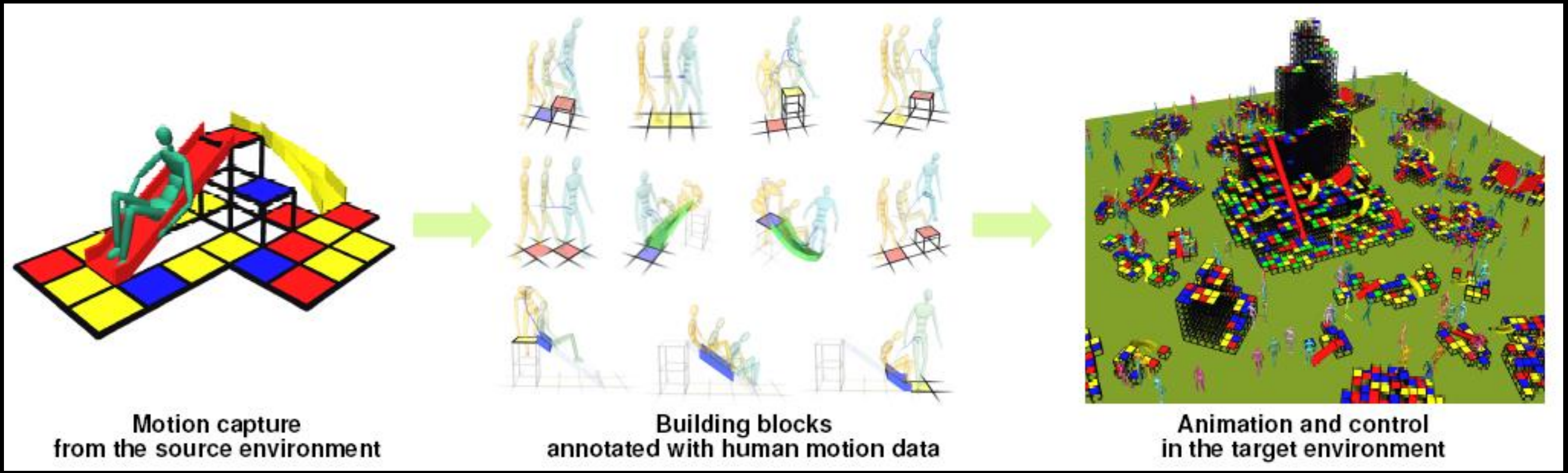
- Liu et al. “Learning Silhouette Features for control of human motion”, TOG’05



[System overview](#)
[Example: swingtime](#)

Application: Generating Motion in Large Virtual Environment

- Lee at al., “Motion Patches,” SIGGRAPH’06
  - Storing environment annotation in database
  - Synthesizing motion according to assembled virtual environment blocks



Application: Plant Animation

- Chris Twigg et al., "Mesh Ensemble Motion Graphs," TOG '07 Demo Video
  - Using precomputed dynamics as motion database
  - Curse of dimensionality: few valid transitions

  - Increasing good transition using asynchronous transition

Inverse-Foley animation: synchronizing rigid-body motions to sound, SIG’15

Neural Motion Graph, SIGGRAPH Asia 2023

Evaluating Motion Graphs

- Reitsma and Pollard, “Evaluating motion graphs for character navigation,” SCA’04
- Analyzing the properties of motion graphs to determine their capabilities with a target environment