Motion Graphs for Character Animation

Parag Chaudhuri
Indian Institute of Technology Bombay

Research Promotion Workshop on
Introduction to Graph and Geometric Algorithms

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ViGIL
VISION, GRAPHICS
& IMAGING LABORATORY

http://www.cse.iitb.ac.in/graphics

http://www.cse.iitb.ac.in/~paragc/research

Outline

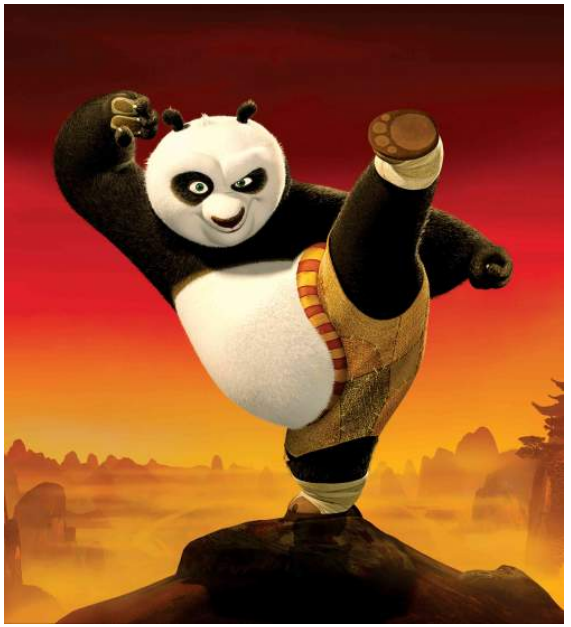
- Introduction
- Character and Motion Data
- Motion Graphs
- Conclusions

Outline

- Introduction
  - The Need for Motion Data
  - Using Motion Data

The Need for Motion Data

Character Animation is about movement



The Need for Motion Data

Creating realistic movement requires lot of skill and time

Source: Sintel, The Durian Open Movie Project

The Need for Motion Data

But it is only one character – how difficult can that be?

The Need for Motion Data

How about a thousand or a million?

Source: Walden Media, Rhythm and Hues Studios, Massive Software

The Need for Motion Data

Capture the movement of performers and use it in animation

Using Motion Data

- Problems
  - Captured data can be voluminous
  - Processing motion data is computationally intensive
  - Capturing all possible motion is impossible
  - Motion Capture is expensive

Using Motion Data

- Solutions
  - Organize and represent data
  - Combine data intelligently to synthesize new motion
  - Simulate physics to dynamically generate new motion

Outline

- Introduction
- Character and Motion Data
  - Character Representation
  - Motion Representation

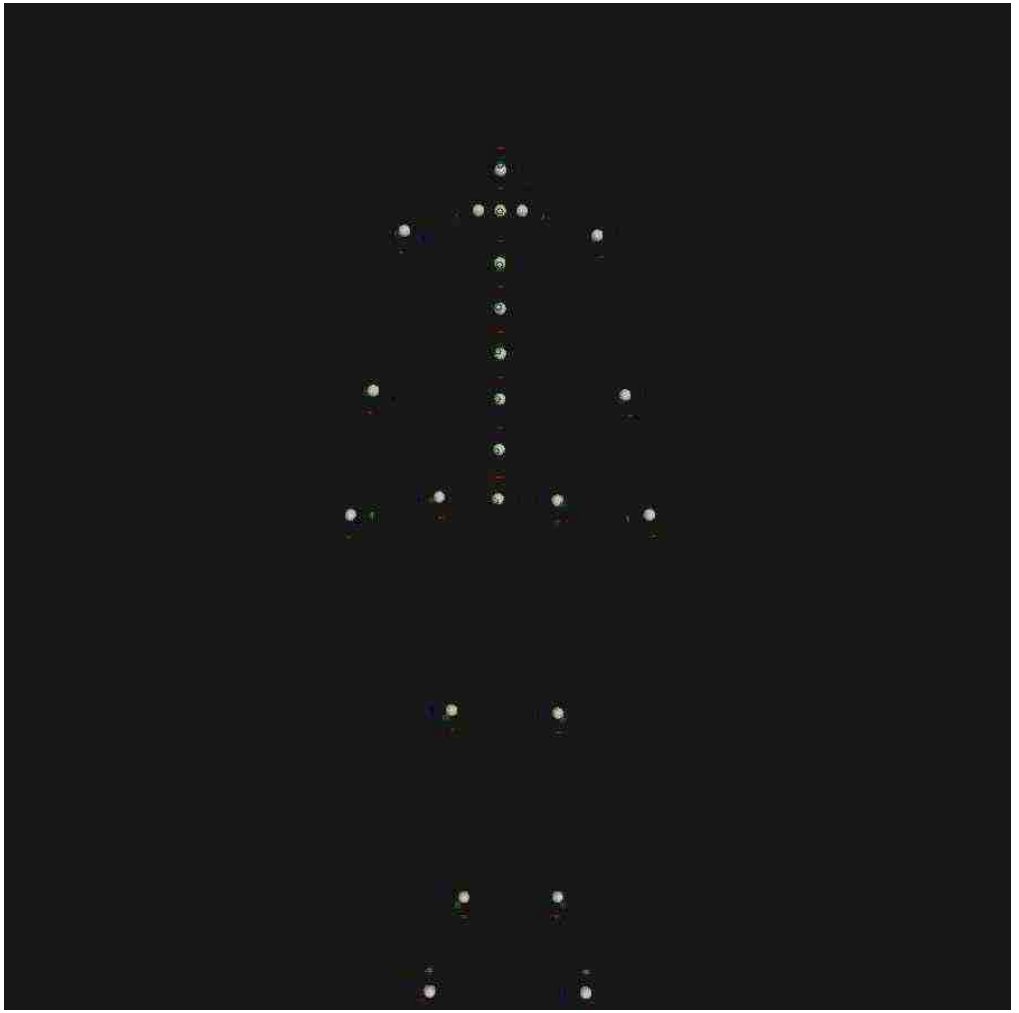
Character Representation

A layered representation for the character

Model Source: MIRALab

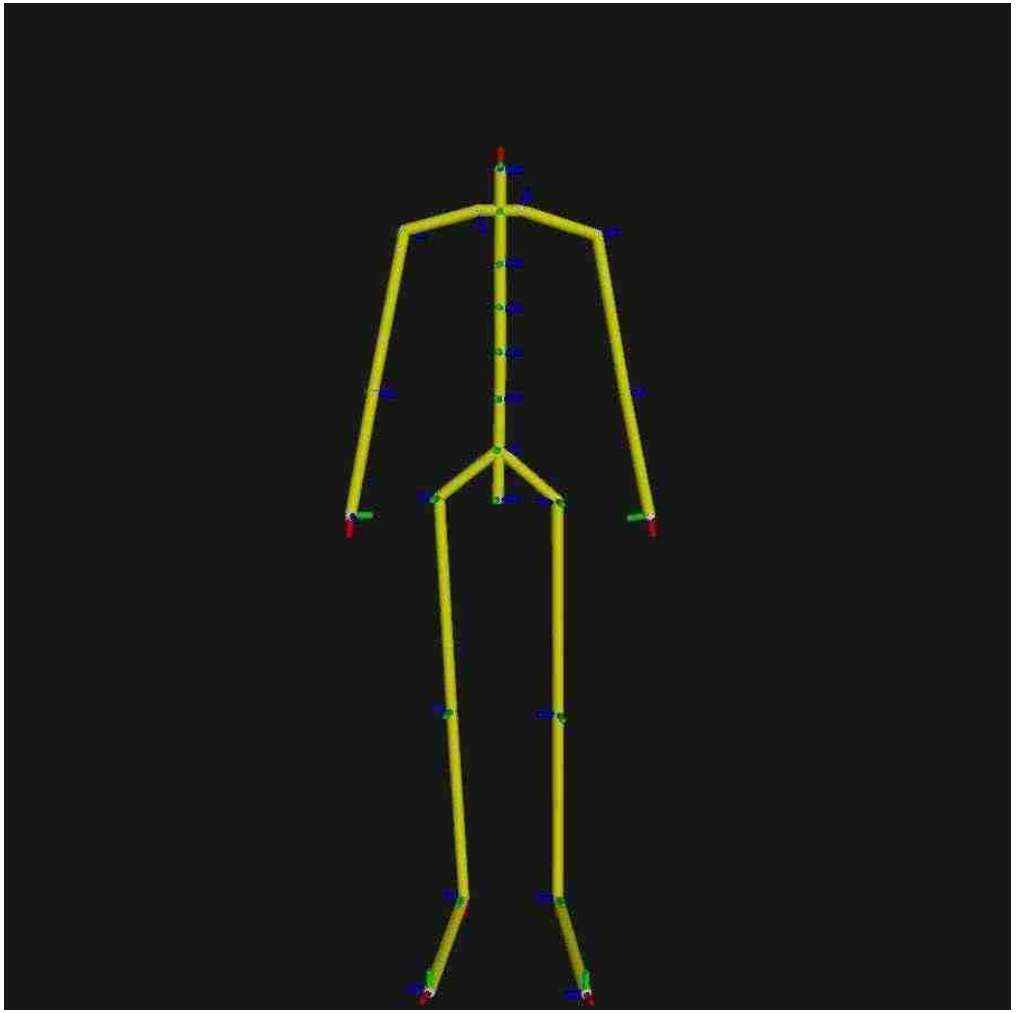
Character Representation

A set of joint with fixed *degrees of freedom* ...



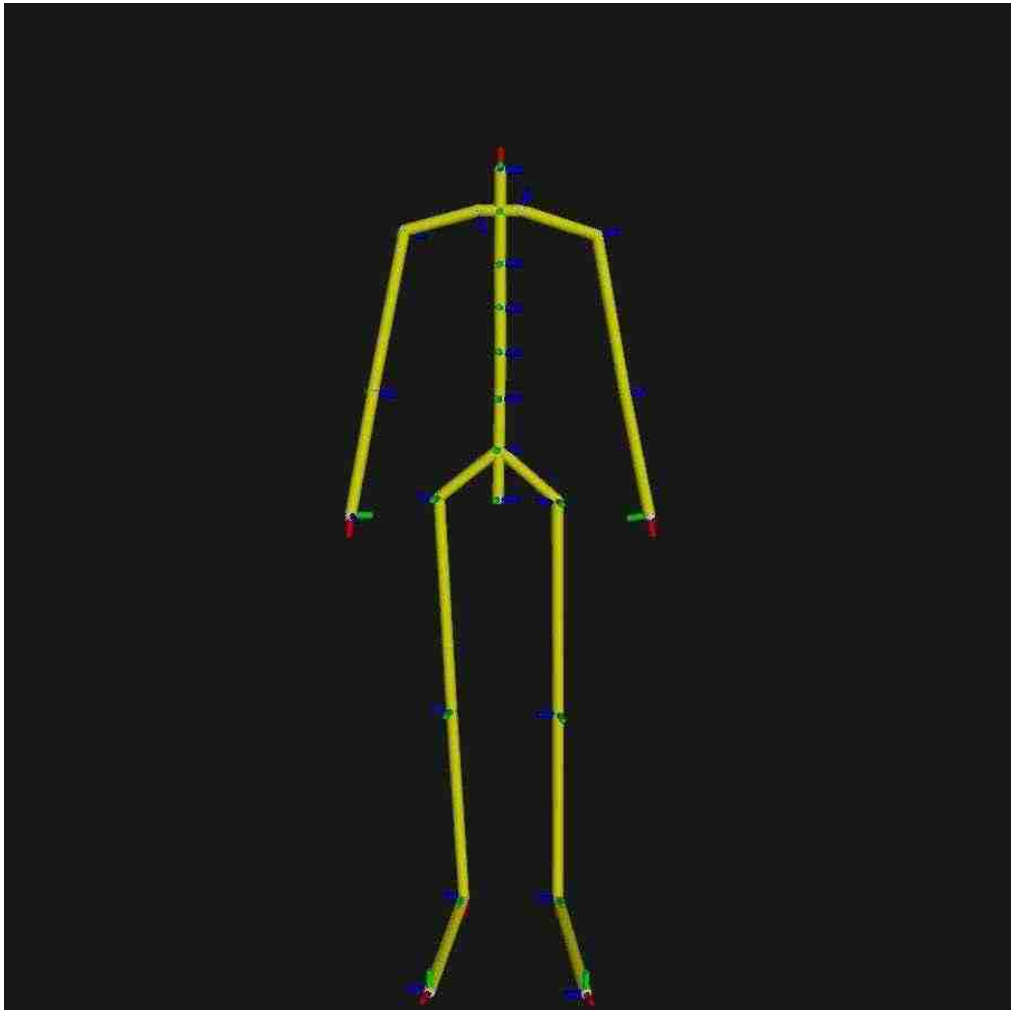
Character Representation

... joined with rigid links form a *skeleton,*



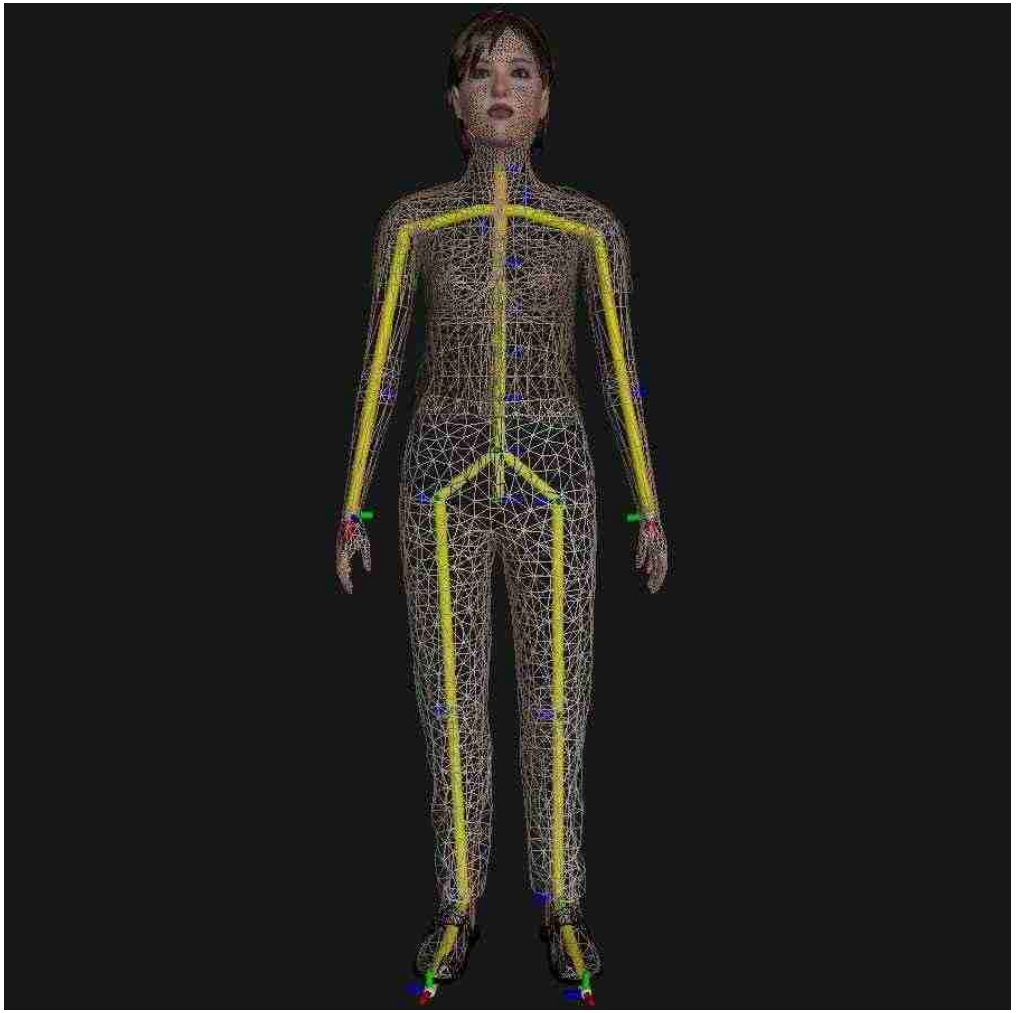
Character Representation

This can be seen as a rooted tree of rigid transformations.



Character Representation

Layered on top of this is a triangle mesh, i.e., the *skin*



Model Source: MIRALab

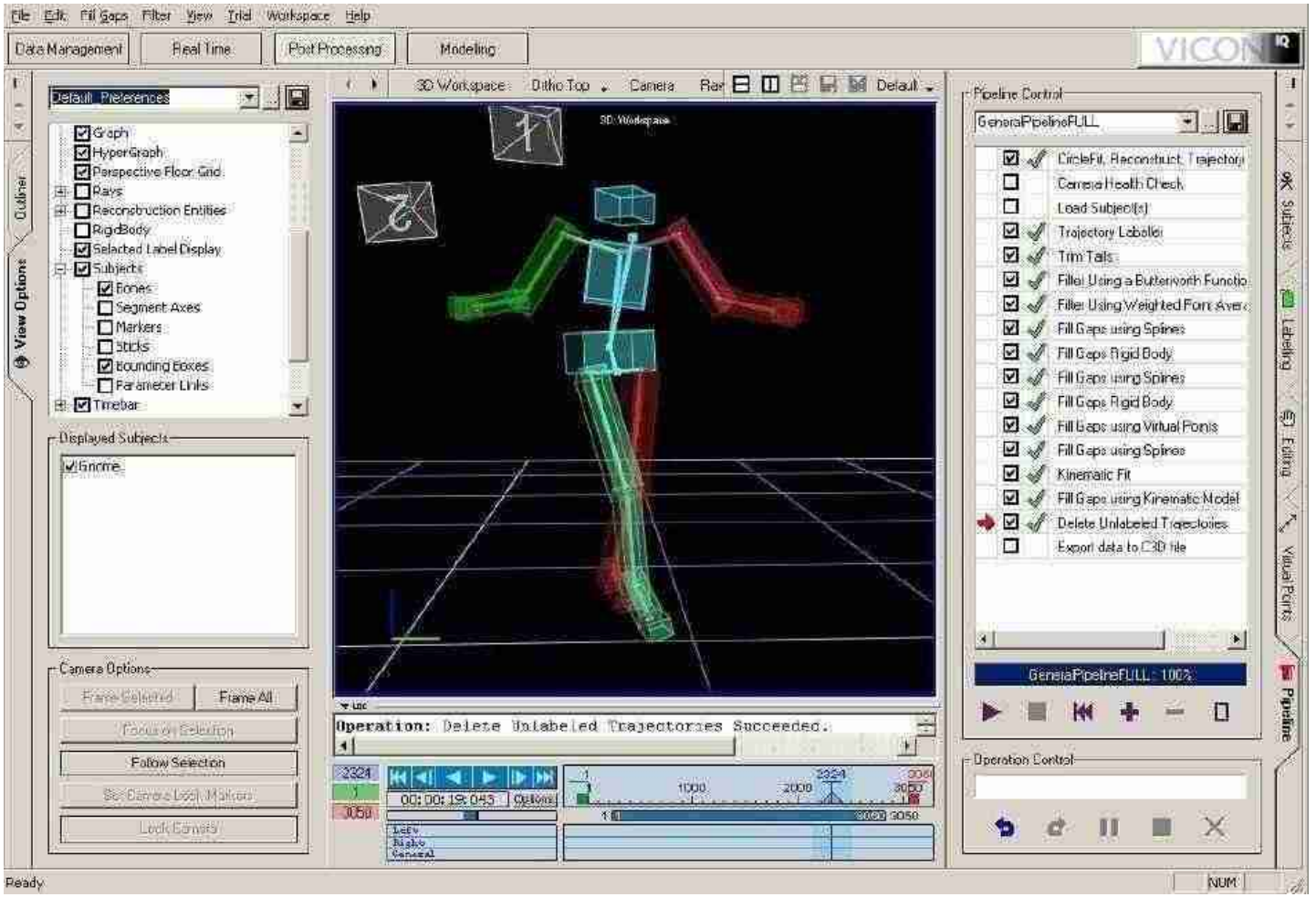
Character Representation

When the skeleton moves, the skin moves along

Model Source: MIRALab

Motion Representation

Motion data is captured as joint trajectories.



Source: VICON

Motion Representation

Motion data is captured as joint trajectories.

Motion Representation

After much processing and cleanup, it is stored in one of many standard formats.

```
HIERARCHY
ROOT Hips
{
        OFFSET  0.00    0.00    0.00
        CHANNELS 6 Xposition Yposition Zposition Zrotation Xrotation Yrotation
        JOINT Chest
        {
                OFFSET   0.00    5.21    0.00
                CHANNELS 3 Zrotation Xrotation Yrotation
                JOINT Neck
                {
                        OFFSET   0.00    18.65   0.00
                        CHANNELS 3 Zrotation Xrotation Yrotation
                        JOINT Head
                        {
                                OFFSET   0.00    5.45    0.00
                                CHANNELS 3 Zrotation Xrotation Yrotation
                                End Site
                                {
                                        OFFSET   0.00    3.87    0.00
                                }
                        }
                }


MOTION
Frames:    2
Frame Time: 0.033333
      8.03      35.01     88.36    -3.41     14.78    -164.35   13.09     40.30    -24.60
      7.88      43.80     0.00     -3.61     -41.45    5.82     10.08     0.00      10.21
      97.95    -23.53    -2.14     -101.86   -80.77    -98.91   0.69      0.03      0.00
     -14.04     0.00     -10.50    -85.52    -13.72    -102.93  61.91    -61.18     65.18
     -1.57      0.69      0.02      15.00     22.78    -5.92     14.93     49.99     6.60
      0.00     -1.14      0.00     -16.58    -10.51    -3.11     15.38     52.66    -21.80
      0.00     -23.95     0.00
      7.81      35.10     86.47    -3.78     12.94    -166.97   12.64     42.57    -22.34
      7.67      43.61     0.00     -4.23     -41.41    4.89     19.10     0.00      4.16
      93.12    -9.69     -9.43      132.67   -81.86    136.80   0.70      0.37      0.00
     -8.62      0.00     -21.82    -87.31    -27.57    -100.09  56.17    -61.56     58.72
     -1.63      0.95      0.03      13.16     15.44    -3.56     7.97      59.29     4.97
      0.00      1.64      0.00     -17.18    -10.02    -3.08     13.56     53.38    -18.07
      0.00     -25.93     0.00
```

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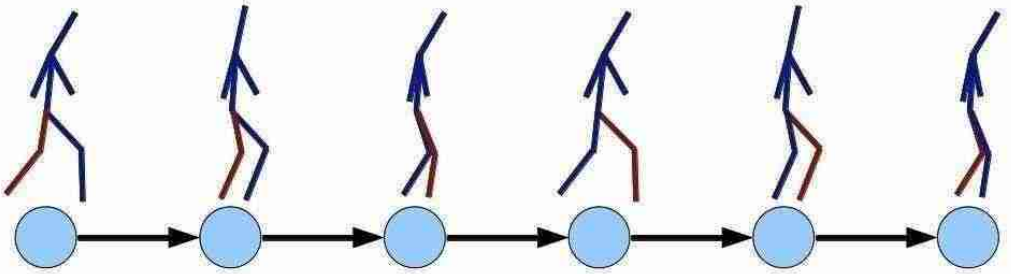
- Introduction
- Character and Motion Data
- Motion Graphs
  - Idea
  - Construction
  - Generating Motion

Motion Graphs - Idea

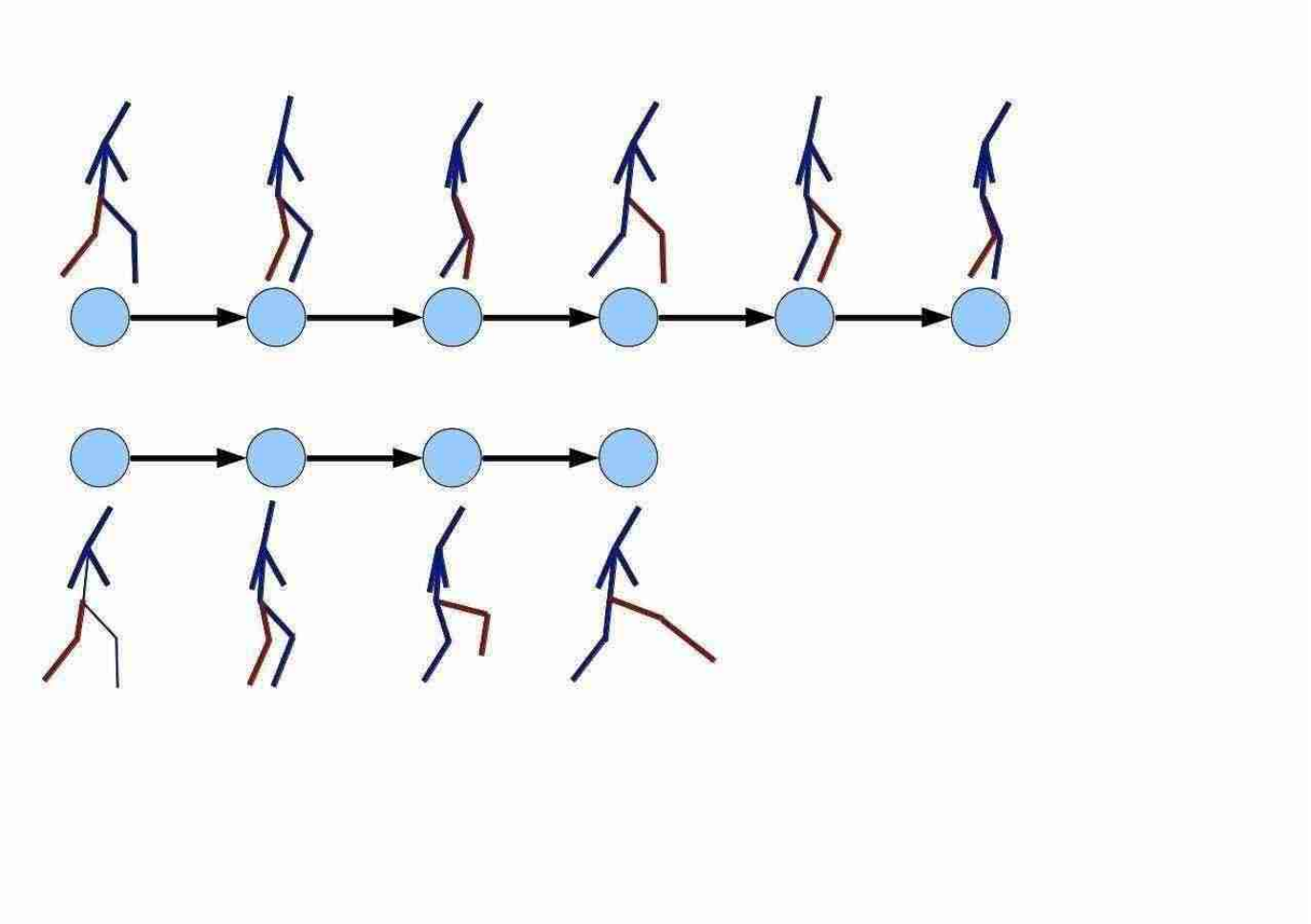
Every motion clip is a graph.

Vertex ~ pose, Edge ~ transition frames.



Motion Graphs - Idea

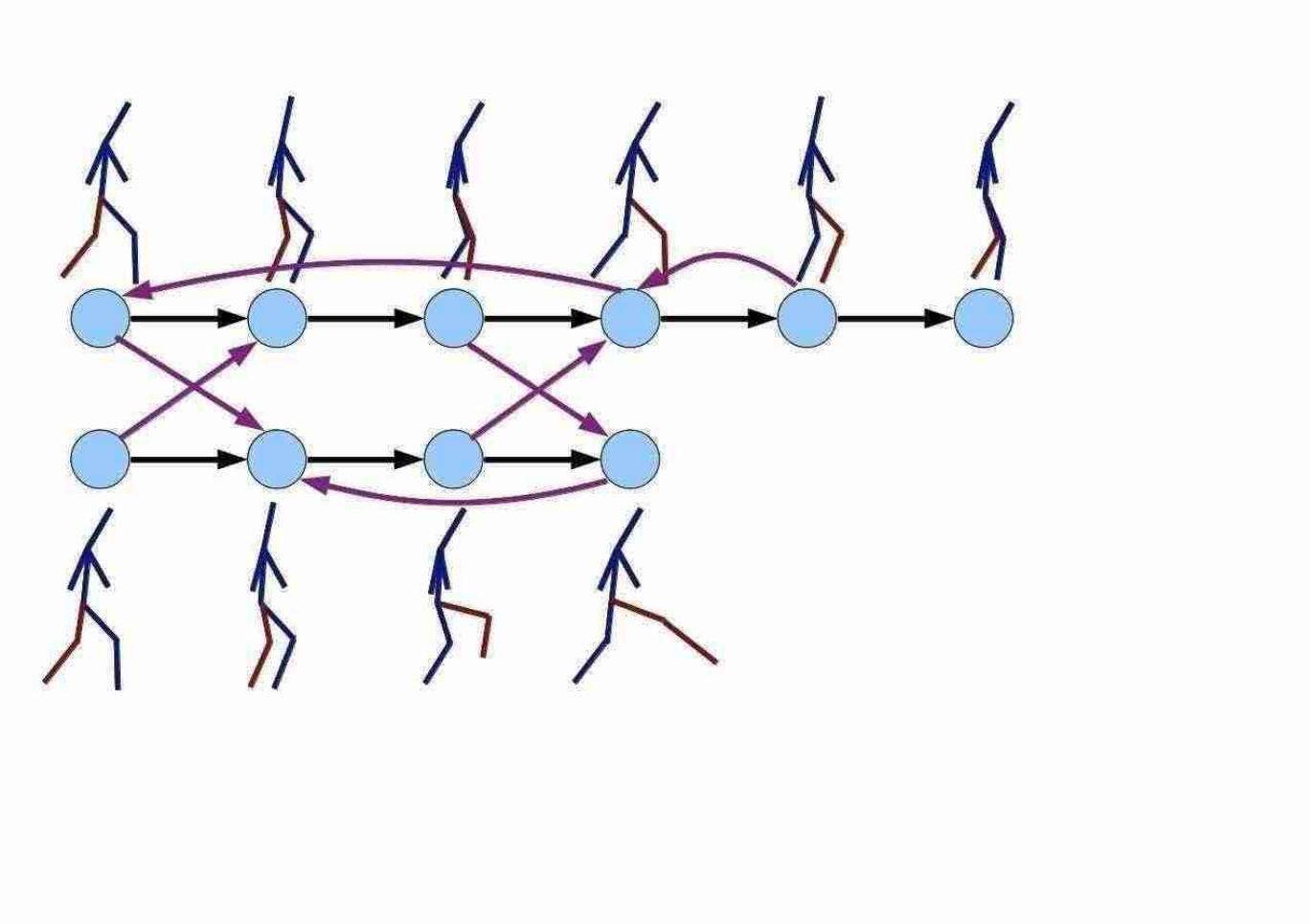
There are many such clips in a motion database.



Motion Graphs - Idea

Find similar poses between clips.

Add transitions between them.



Motion Graphs - Idea

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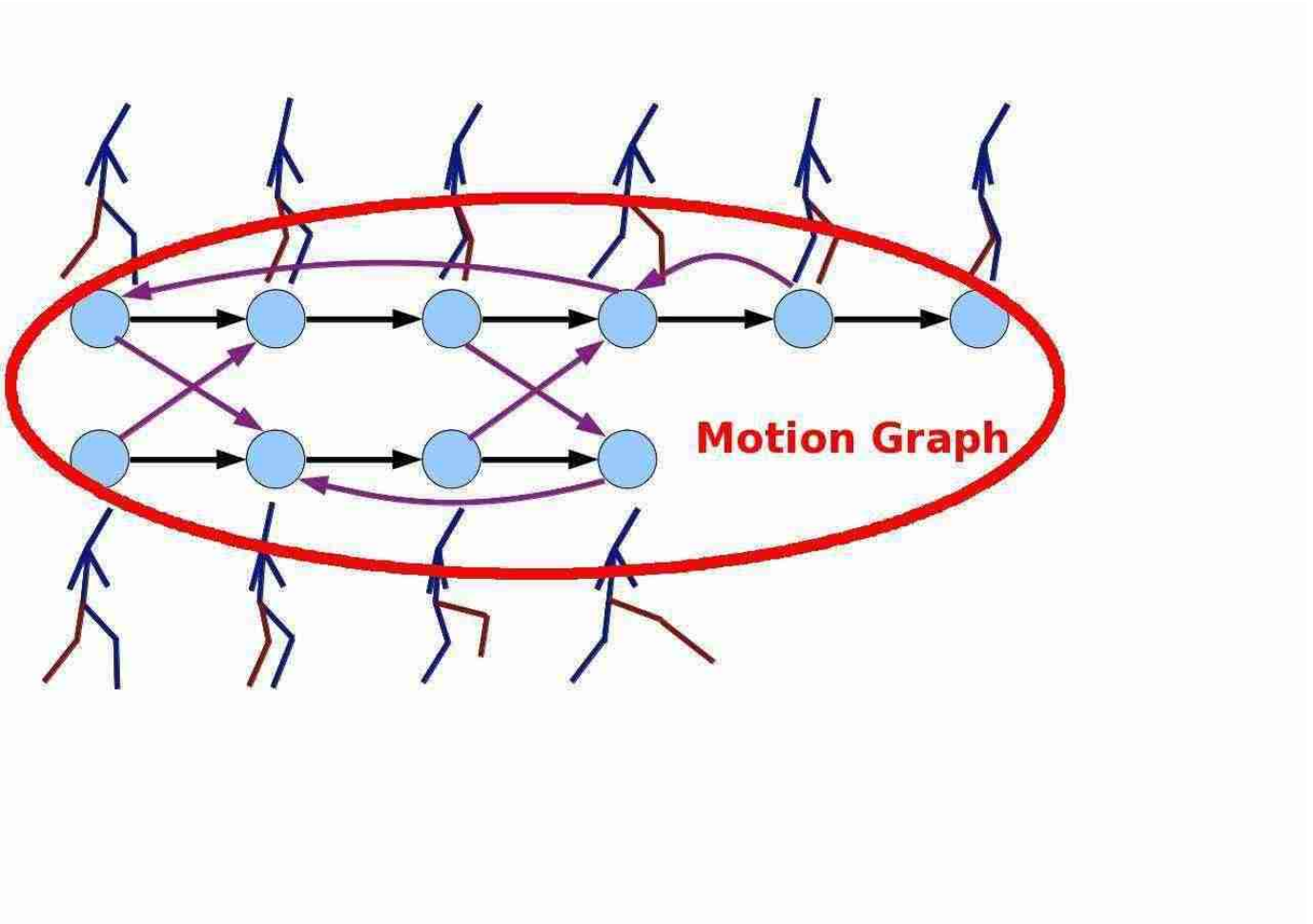
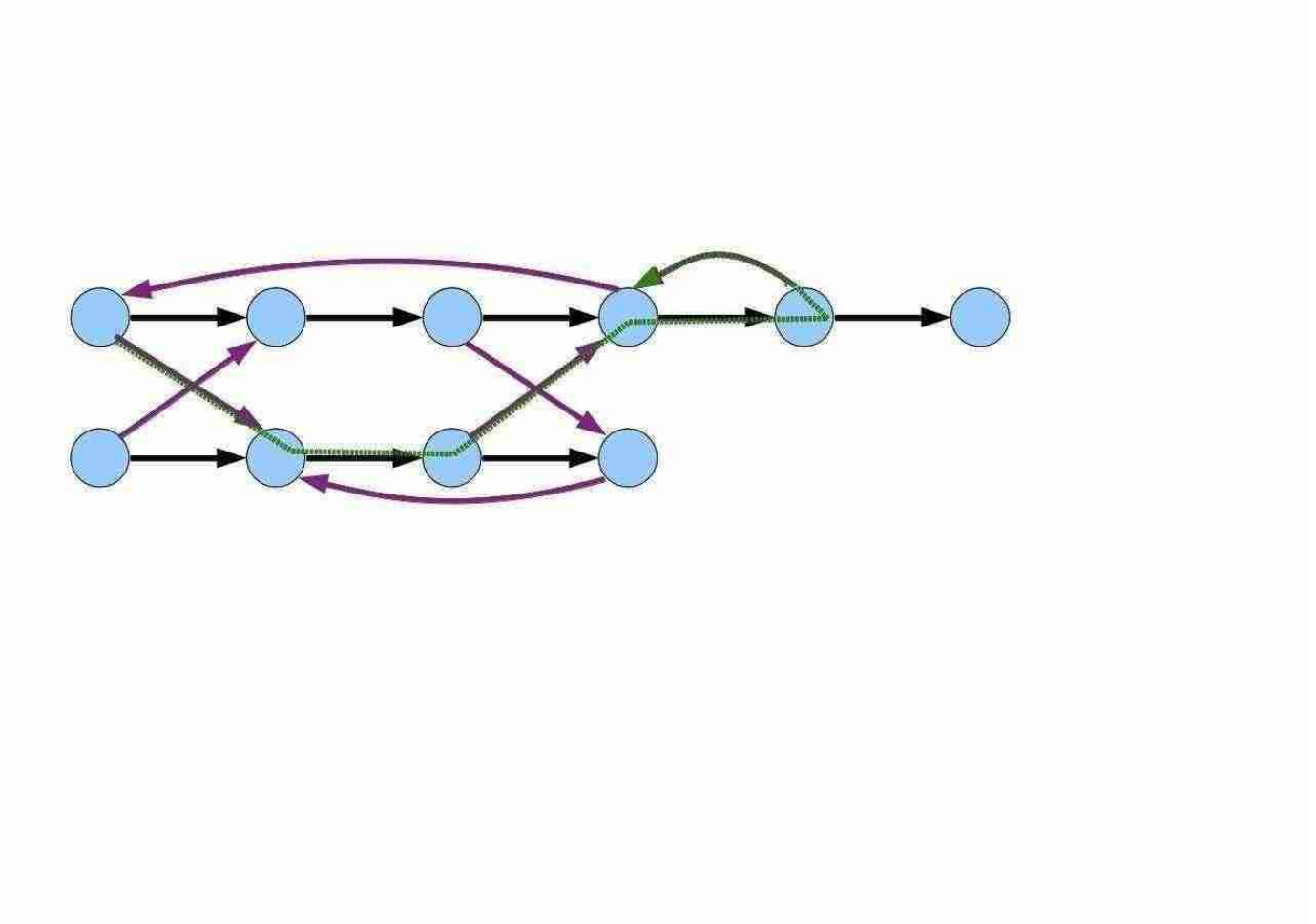
Add transitions between them.



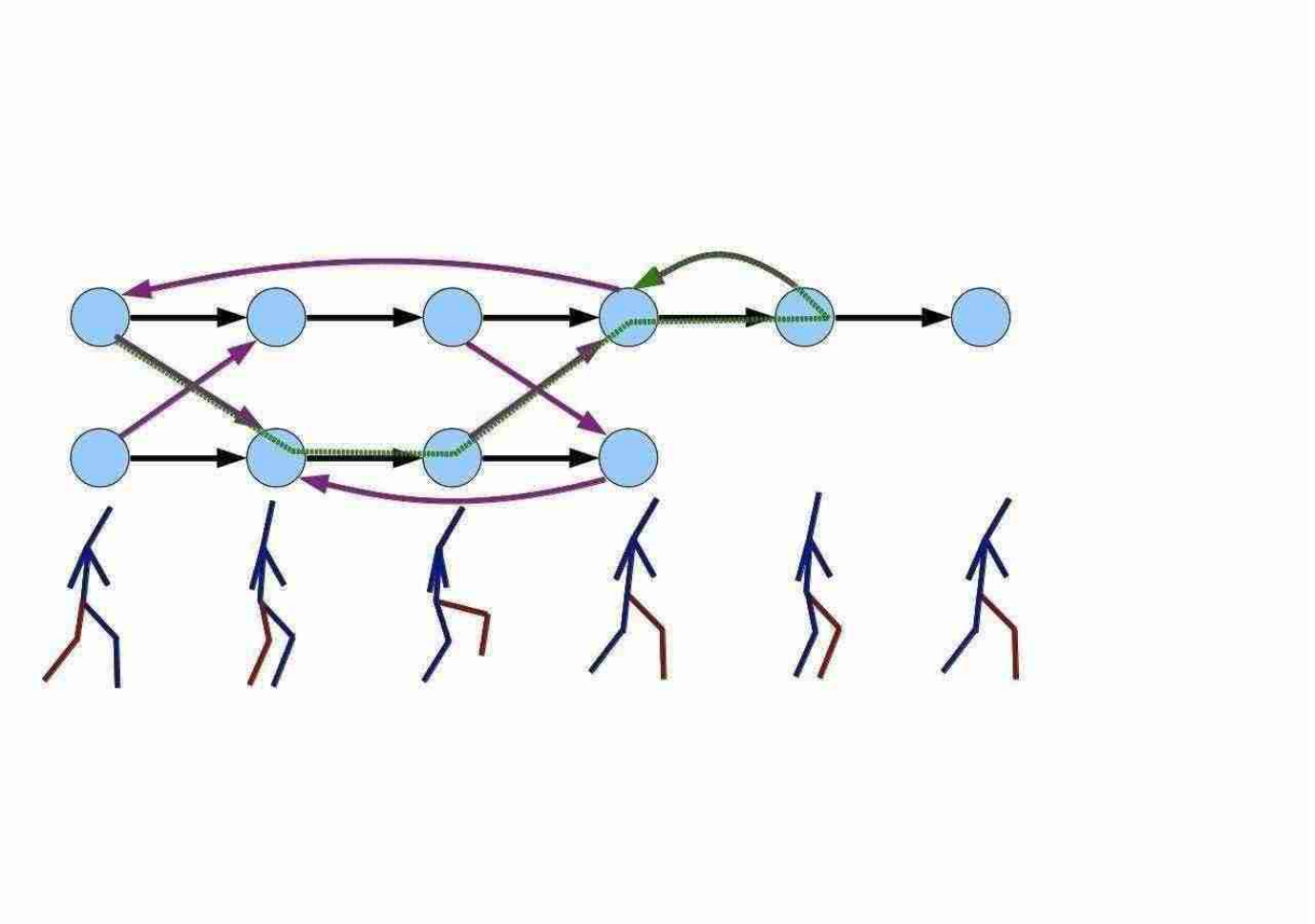
Motion Graphs - Idea

Now any walk on this graph...



Motion Graphs - Idea

...generates a new motion.



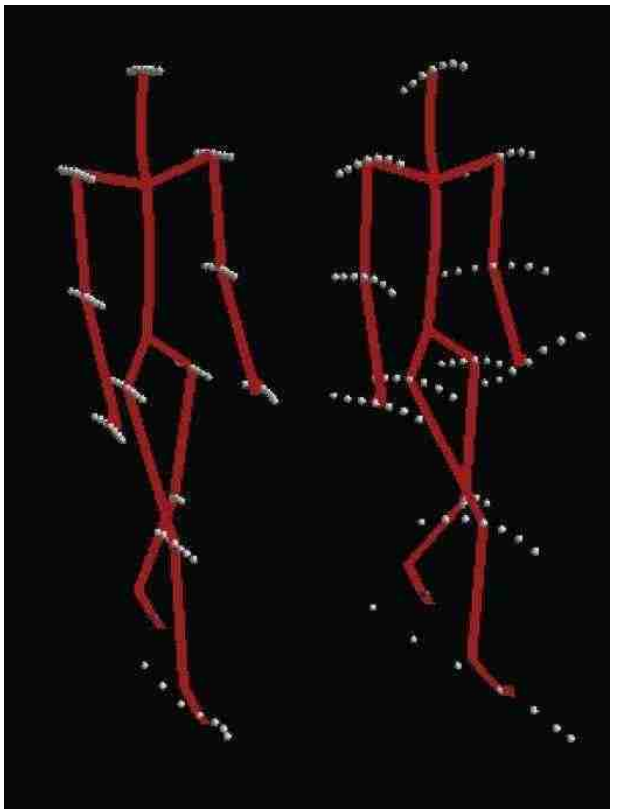
Motion Graphs - Construction

Similarity between poses across clips

- Identify compatible coordinate systems.
- Account for changes in body pose.
- Account for changes in joint-velocity and acceleration.
- Relative importance of joints.

Motion Graphs - Construction

$$D(P_i, P_j) = \min_{\theta, x_o, z_o} \sum_{k=1}^{n} \omega_k \| p_i^k - T_{\theta, x_o, z_o} p_j^k \|^2$$

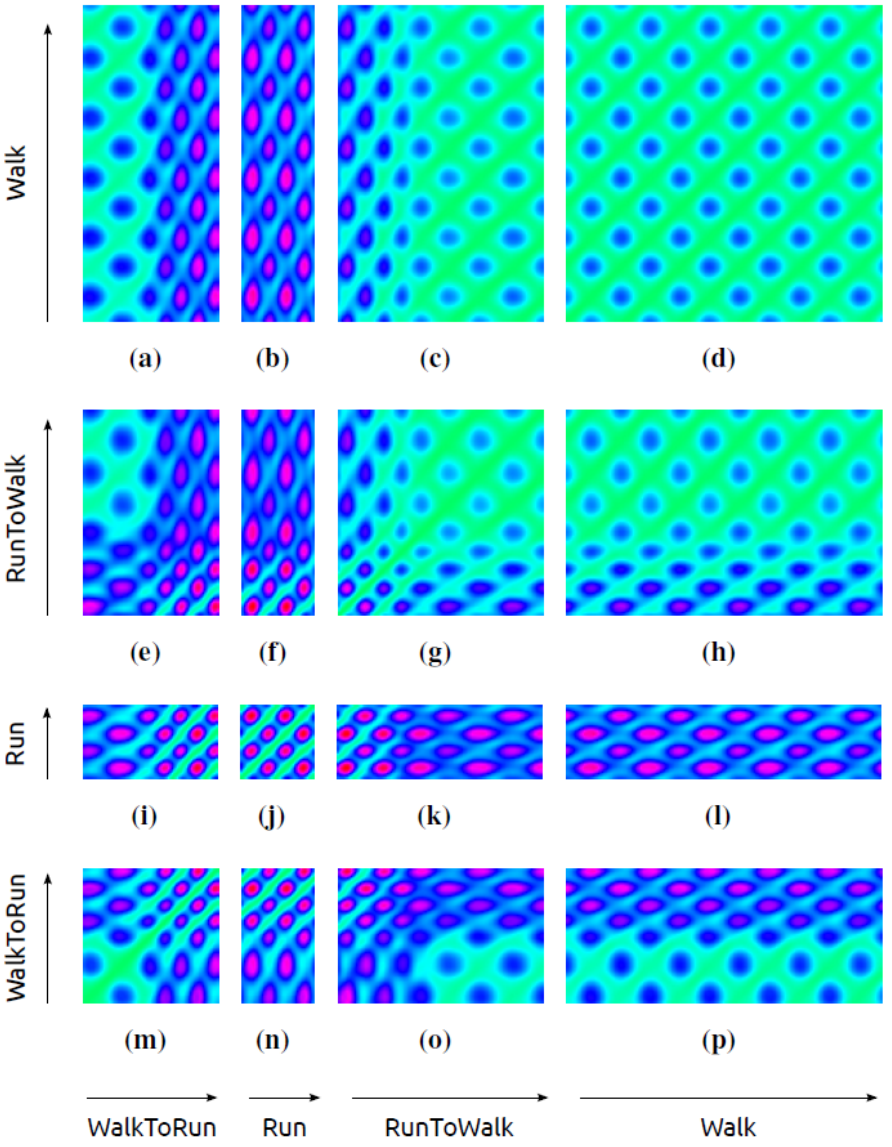


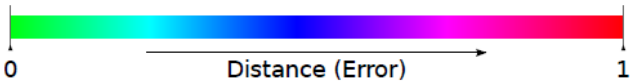
Compute distance over a window of $2L+1$ frames centered at P_i and P_j

Constructing Good Quality Motion Graphs for Realistic Human Animation, Limin Zhaog, PhD Thesis, University of Pennsylvania, 2009.

Motion Graphs, Lucas Kovar, Michael Gleicher and Frederic Pighin, SIGGRAPH 2002.

Motion Graphs - Construction





(q)

Fig.	Y-axis clip *	X-axis clip*
(a)	Walk	WalkToRun
(b)	Walk	Run
(c)	Walk	RunToWalk
(d)	Walk	Walk
(e)	RunToWalk	WalkToRun
(f)	RunToWalk	Run
(g)	RunToWalk	RunToWalk
(h)	RunToWalk	Walk
(i)	Run	WalkToRun
(j)	Run	Run
(k)	Run	RunToWalk
(l)	Run	Walk
(m)	WalkToRun	WalkToRun
(n)	WalkToRun	Run
(o)	WalkToRun	RunToWalk
(p)	WalkToRun	Walk

*Note: The lower left corner represents beginning of both clips in each figure.

Motion Graphs in Blender, Mihir Gokani and Parag Chaudhuri, Blender Conference, 2011

Motion Graphs - Construction

- Create transitions between similar frames.
- Retain the largest strongly connected component.
- Linear interpolation of translations, SLERP for rotations.

Motion Graphs, Lucas Kovar, Michael Gleicher and Frederic Pighin, SIGGRAPH 2002.

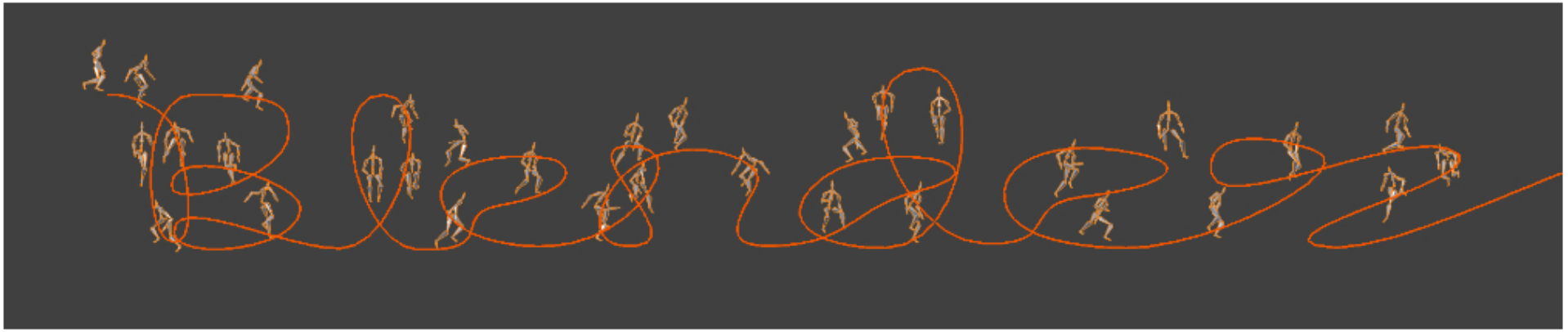
Motion Graphs in Blender, Mihir Gokani and Parag Chaudhuri, Blender Conference, 2011

Motion Graphs - Construction

Demo

Motion Graphs – Generating Motion

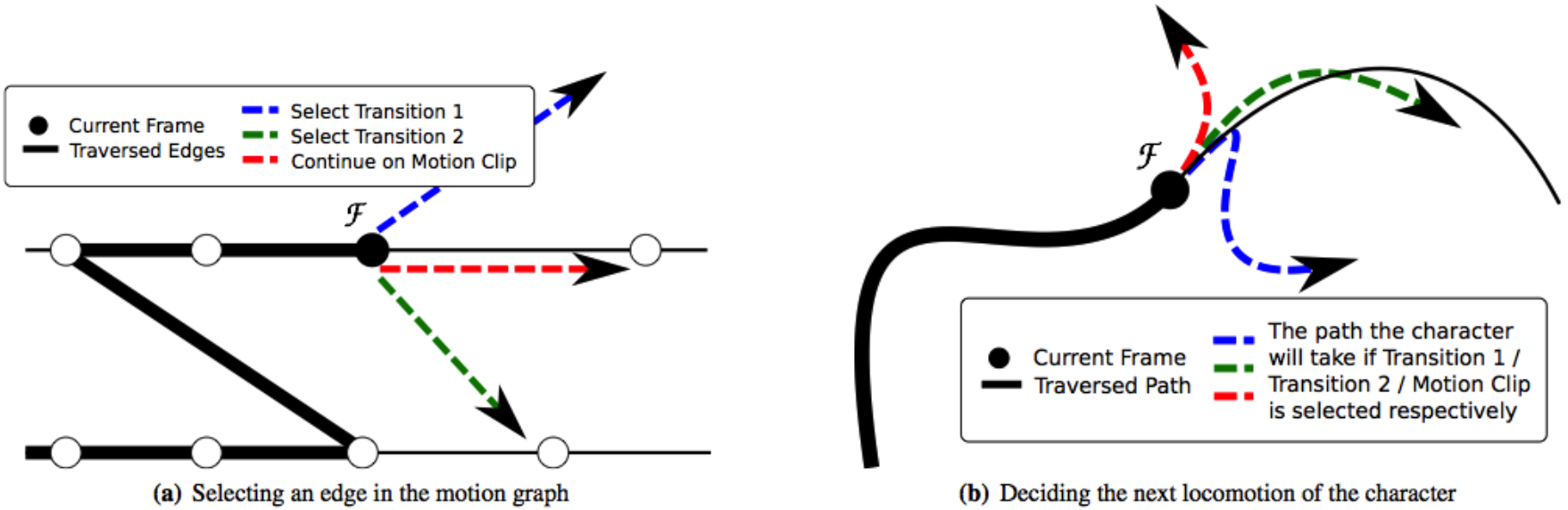
- Follow a path – minimize a "path follow" function during the graph walk.



Path Synthesis for Motion Graphs in Blender, Mihir Gokani and Parag Chaudhuri, Blender Conference, 2012

Motion Graphs – Generating Motion

- Follow a path – minimize a "path follow" function during the graph walk.



(a) Selecting an edge in the motion graph

(b) Deciding the next locomotion of the character

Figure 1: *Selecting an edge in the motion graph is equivalent to deciding next locomotion of the character*

Path Synthesis for Motion Graphs in Blender, Mihir Gokani and Parag Chaudhuri, Blender Conference, 2012

Motion Graphs – Generating Motion

- Follow a path – minimize a "path follow" function during the graph walk.

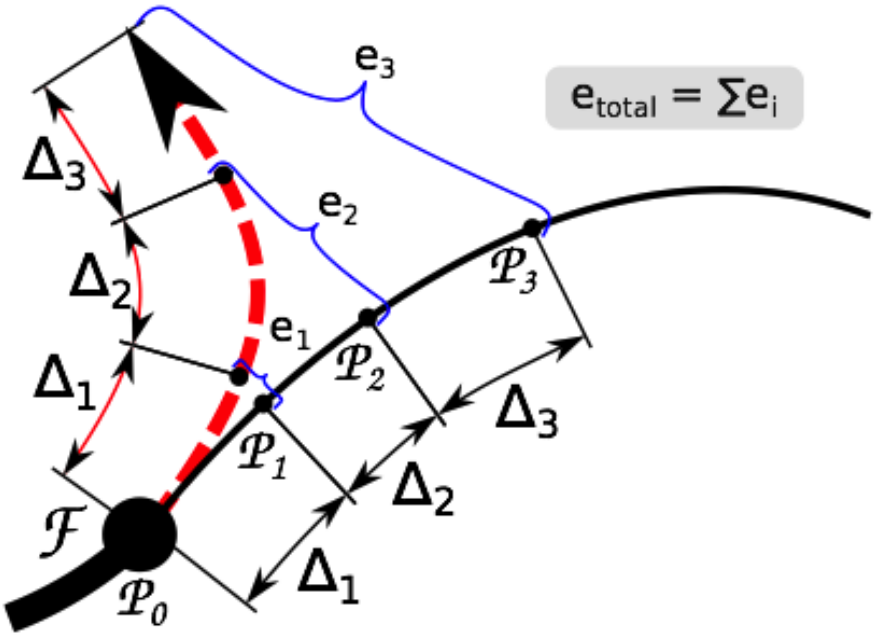
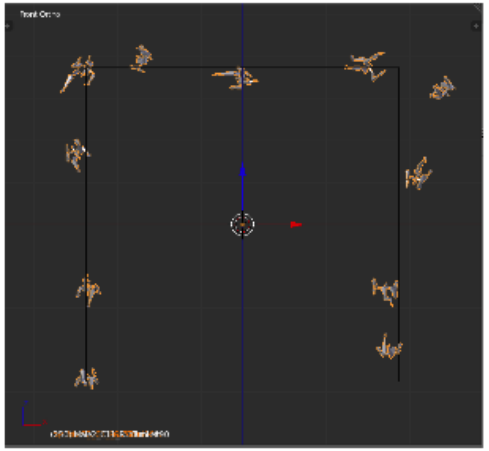


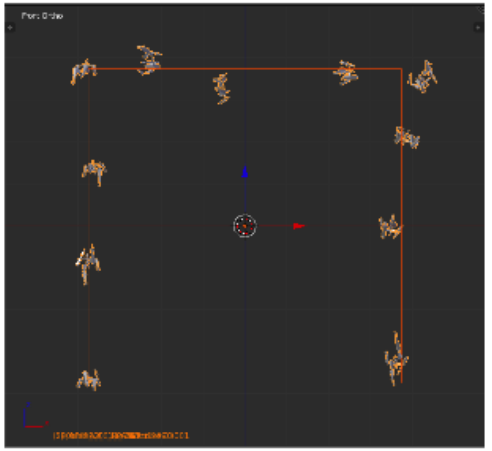
Figure 5: *Finding the deviation of motion from path segment*

Path Synthesis for Motion Graphs in Blender, Mihir Gokani and Parag Chaudhuri, Blender Conference, 2012

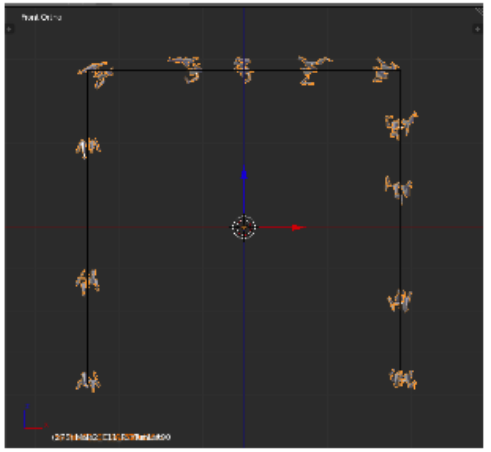
Motion Graphs – Generating Motion



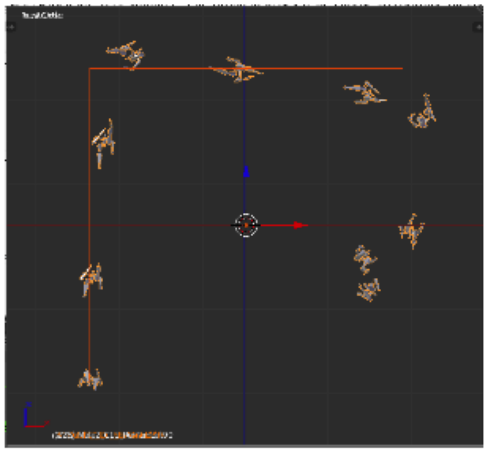
(a) Threshold = 50%, Prediction = 0 frames, No Grouping



(b) Threshold = 50%, Prediction = 5 frames, No Grouping

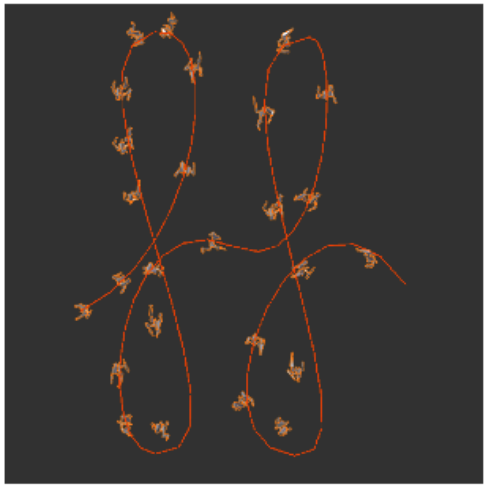


(c) Threshold = 50%, Prediction = 15 frames, No Grouping



(d) Threshold = 50%, Prediction = 15 frames, Inbound and Outbound Grouping

(e) Threshold = 50%, Prediction = 0 frames, Inbound and Outbound Grouping



(f) Threshold = 50%, Prediction = 15 frames, Inbound and Outbound Grouping

Path Synthesis for Motion Graphs in Blender, Mihir Gokani and Parag Chaudhuri, Blender Conference, 2012

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Conclusions

- Motion Graphs are very useful in character animation.
- Extensively used for real-time and offline animation synthesis.
- Active area of research.
- Future going toward a mix of physics-based simulation and motion capture.

Thank You

Questions?

Image source:Despicable Me, Illumination Entertainment 2010