CS-184: Computer Graphics

Lecture #20: Motion Capture

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V2005-F20-1.0

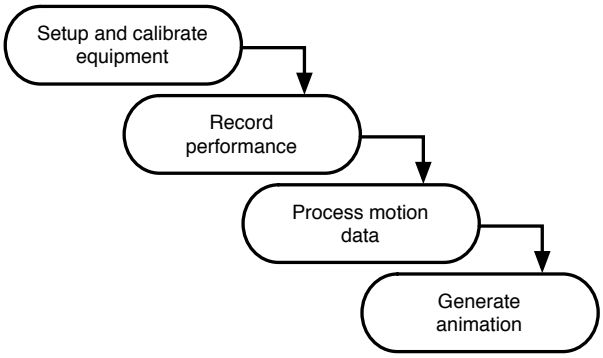
Today

- Motion Capture

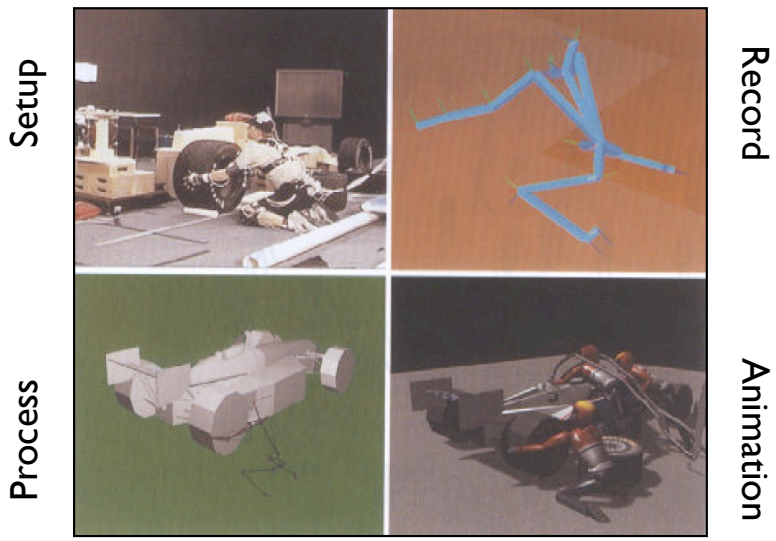
Motion Capture

- Record motion from physical objects
- Use motion to animate virtual objects

Simplified Pipeline:



Basic Pipeline



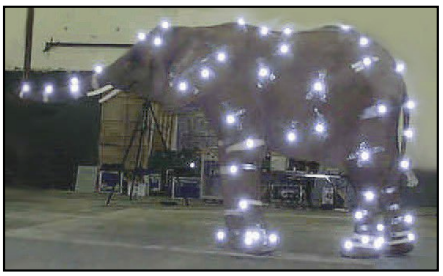
From Rose, *et al.*, 1998

What types of objects?

- Human, whole body
- Portions of body
- Facial animation
- Animals
- Puppets
- Other objects

Capture Equipment

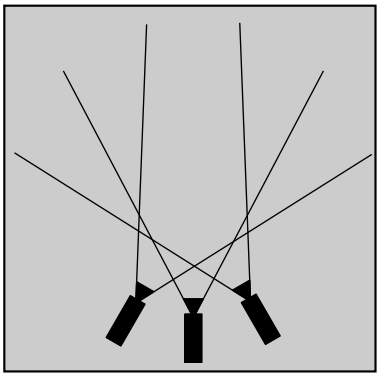
- Passive Optical
  - Reflective markers
  - IR (typically) illumination
  - Special cameras
    - Fast, high res., filters
  - Triangulate for positions



Images from Motion Analysis

Capture Equipment

- Passive Optical Advantages
  - Accurate
  - May use many markers
  - No cables
  - High frequency
- Disadvantages
  - Requires lots of processing
  - Expensive systems
  - Occlusions
  - Marker swap
  - Lighting / camera limitations



Capture Equipment

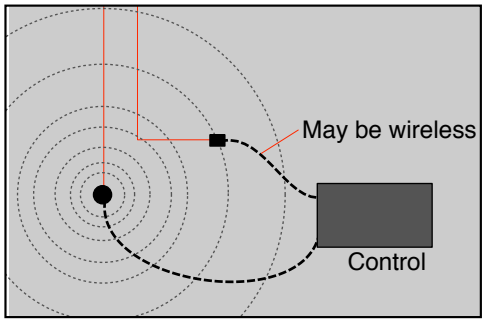
- Active Optical
  - Similar to passive but uses LEDs
  - Blink IDs, no marker swap
  - Number of markers trades off w/ frame rate

Phoenix Technology

Phase Space

Capture Equipment

- Magnetic Trackers
  - Transmitter emits field
  - Trackers sense field
  - Trackers report position and orientation

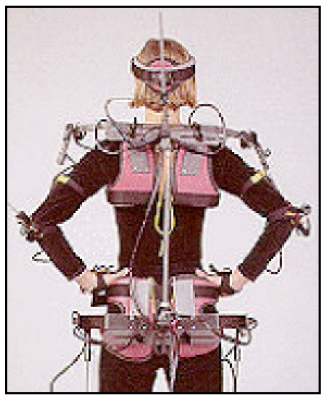


Capture Equipment

- Electromagnetic Advantages
  - 6 DOF data
  - No occlusions
  - Less post processing
  - Cheaper than optical
- Disadvantages
  - Cables
  - Problems with metal objects
  - Low(er) frequency
  - Limited range
  - Limited number of trackers

Capture Equipment

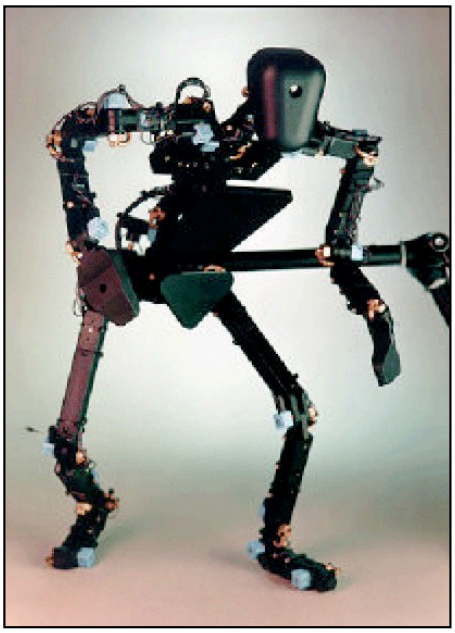
- Electromechanical



Analogus

Capture Equipment

- Puppets



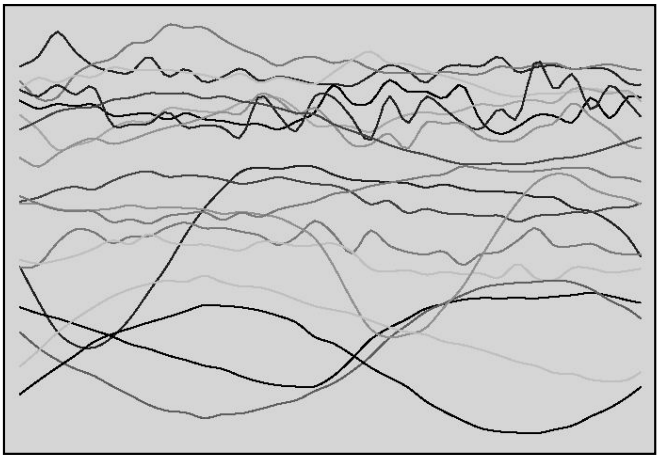
Performance Capture

- Many studios regard *Motion* Capture as evil
  - Synonymous with low quality motion
  - No directive / creative control
  - Cheap
- *Performance* Capture is different
  - Use mocap device as an expressive input device
  - Similar to digital music and MIDI keyboards

Manipulating Motion Data

- Basic tasks
  - Adjusting
  - Blending
  - Transitioning
  - Retargeting
- Building graphs

Nature of Motion Data

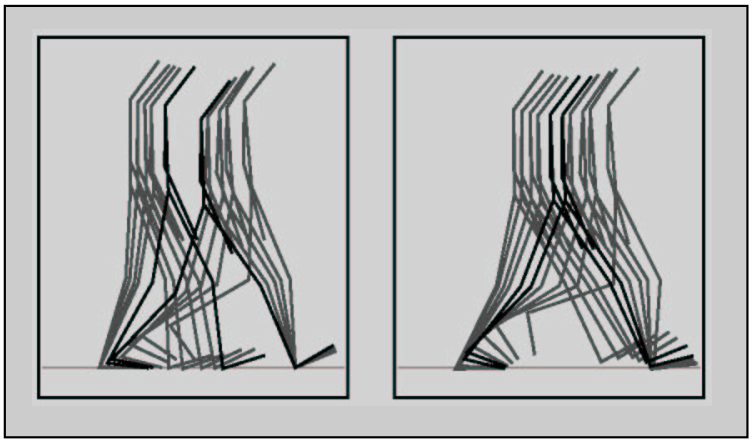


Witkin and Popovic, 1995

Subset of motion curves from captured walking motion.

Adjusting

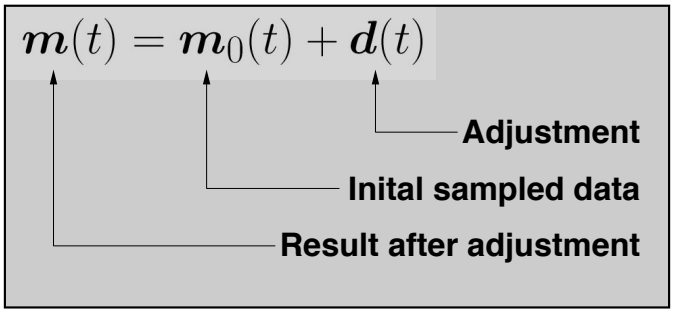
- IK on single frames will not work



Gleicher, SIGGRAPH 98

Adjusting

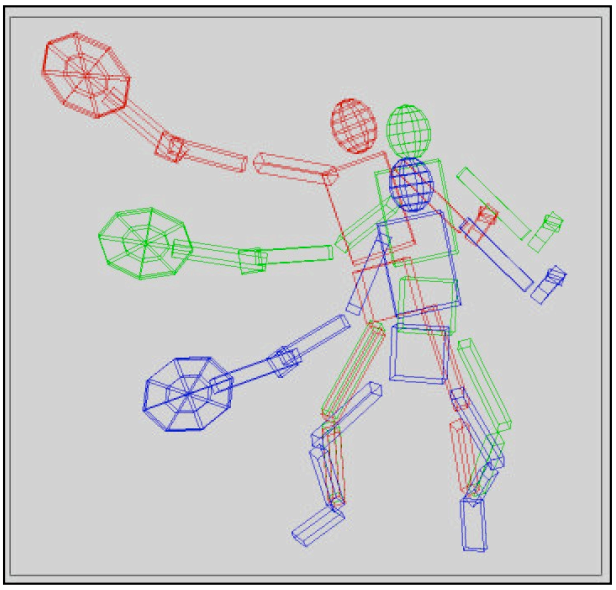
- Define desired motion function in parts



Adjusting

- Select adjustment function from "some nice space"
  - Example C2 B-splines
- Spread modification over reasonable period of time
  - User selects support radius

Adjusting

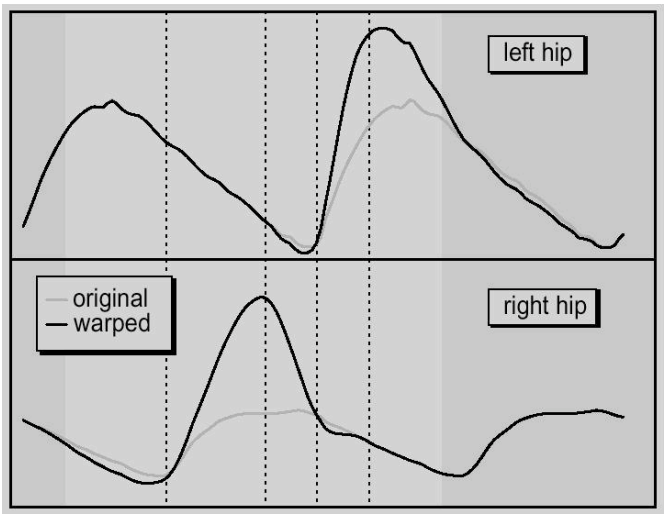


IK uses control points of the B-spline now

Example:
- position racket
- fix right foot
- fix left toes
- balance

Witkin and Popovic SIGGRAPH 95

Adjusting



Witkin and Popovic SIGGRAPH 95

What if adjustment periods overlap?

Blending

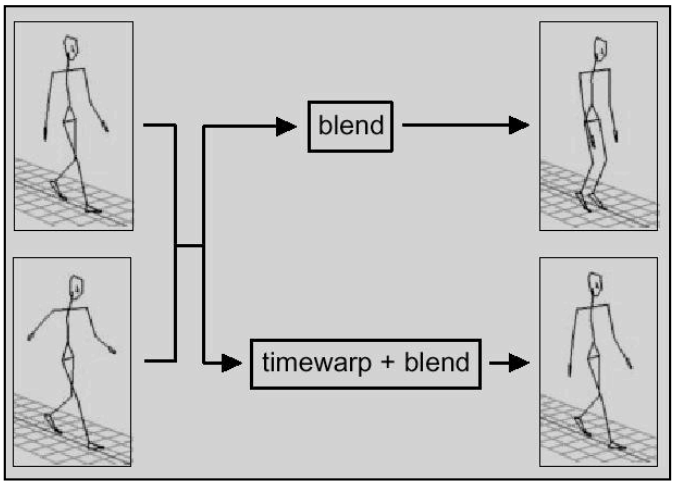
- Given two motions make a motion that combines qualities of both

$$\boldsymbol{m}_\alpha(t) = \alpha \boldsymbol{m}_a(t) + (1-\alpha)\boldsymbol{m}_b(t)$$

- Assume same DOFs
- Assume same parameter mappings

Blending

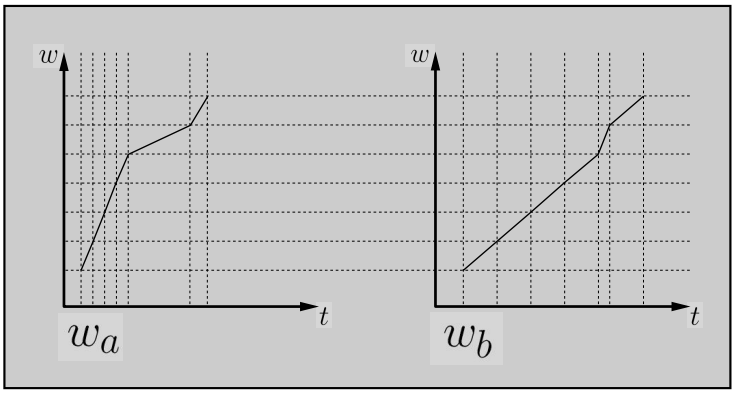
- Consider blending *slow-walk* and *fast-walk*



Bruderlin and Williams, SIGGRAPH 95

Blending

- Define timewarp functions to align features in motion



Normalized time is w

Blending

- Blend in normalized time

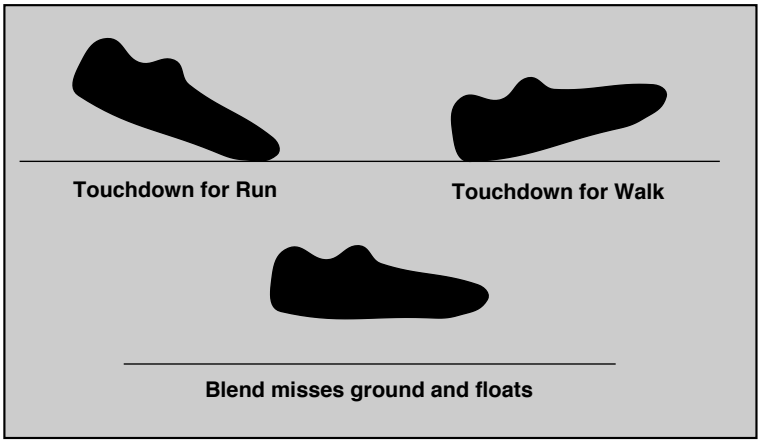
$$\boldsymbol{m}_\alpha(w) = \alpha \boldsymbol{m}_a(w_a) + (1-\alpha)\boldsymbol{m}_b(w_b)$$

- Blend playback rate

$$\frac{\mathrm{d}t}{\mathrm{d}w} = \alpha \frac{\mathrm{d}t}{\mathrm{d}w_a} + (1-\alpha)\alpha \frac{\mathrm{d}t}{\mathrm{d}w_b}$$

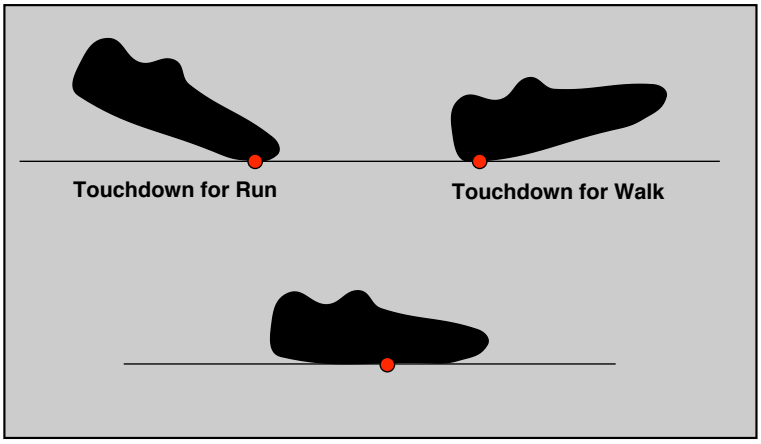
Blending

- Blending may still break features in original motions



Blending

- Add explicit constrains to key points
  - Enforce with IK over time

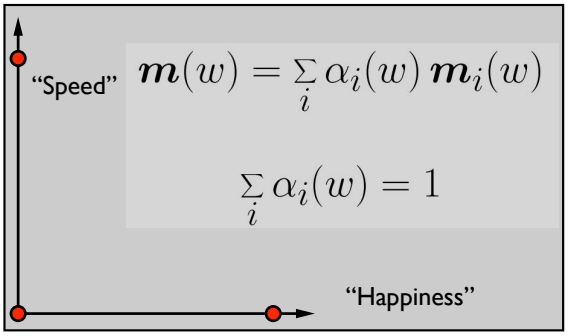


Blending / Adjustment

- Short edits will tend to look acceptable
- Longer ones will often exhibit problems
- Optimize to improve blends / adjustments
  - Add quality metric on adjustment
  - Minimize accelerations / torques
  - Explicit smoothness constraints
  - Other criteria...

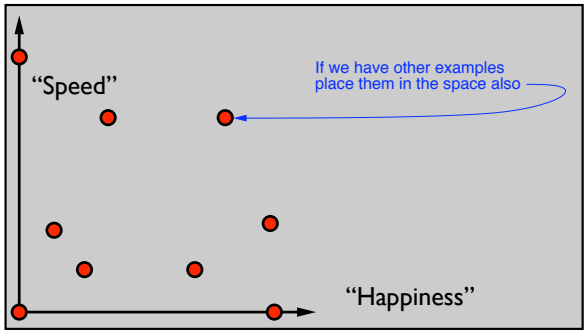
Multivariate Blending

- Extend blending to multivariate interpolation



Multivariate Blending

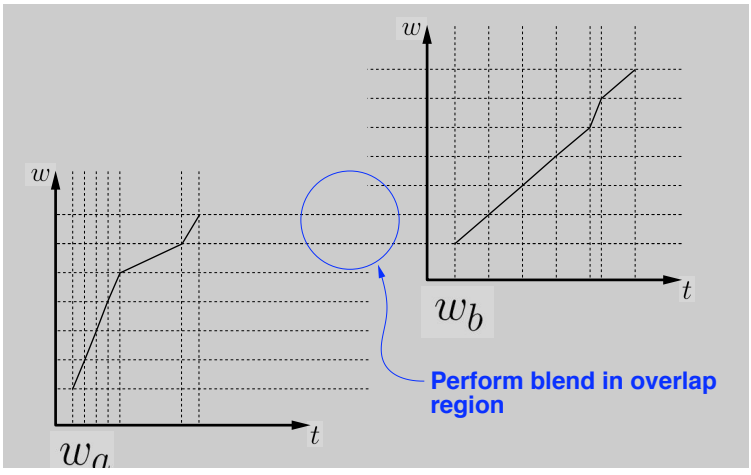
- Extend blending to multivariate interpolation



Use standard scattered-data interpolation methods

Transitions

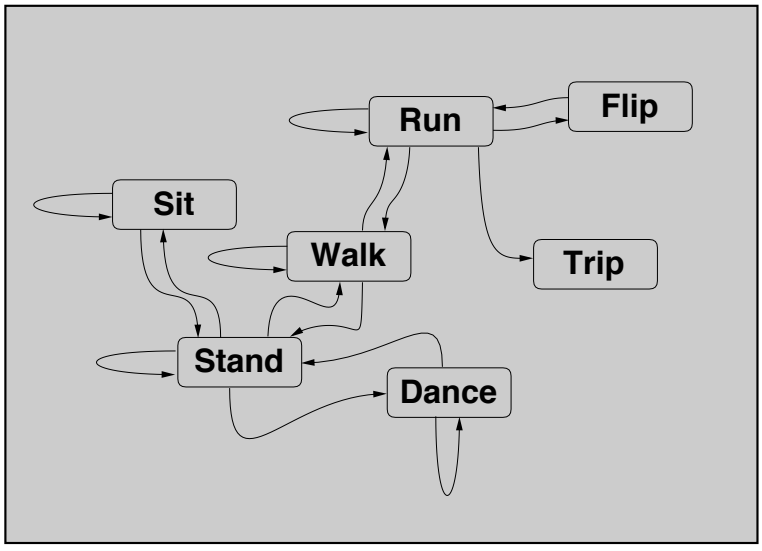
- Transition from one motion to another



Cyclification

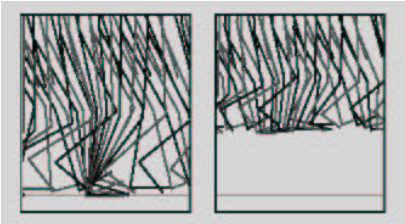
- Special case of transitioning
- Both motions are the same
- Need to modify beginning and end of a motion simultaneously

Transition Graphs



Retargeting

- Adapt motion from one character to another



From Gleicher, SIGGRAPH 1998

Suggested Reading

- *Fourier principles for emotion-based human figure animation,* Unuma, Anjyo, and Takeuchi, SIGGRAPH 95
- *Motion signal processing,* Bruderlin and Williams, SIGGRAPH 95
- *Motion warping,* Witkin and Popovic, SIGGRAPH 95
- *Efficient generation of motion transitions using spacetime constrains,* Rose *et al.,* SIGGRAPH 96
- *Retargeting motion to new characters,* Gleicher, SIGGRAPH 98
- *Verbs and adverbs: Multidimensional motion interpolation,* Rose, Cohen, and Bodenheimer, IEEE: Computer Graphics and Applications, v. 18, no. 5, 1998