CS-184: Computer Graphics

Lecture #18: Motion Capture

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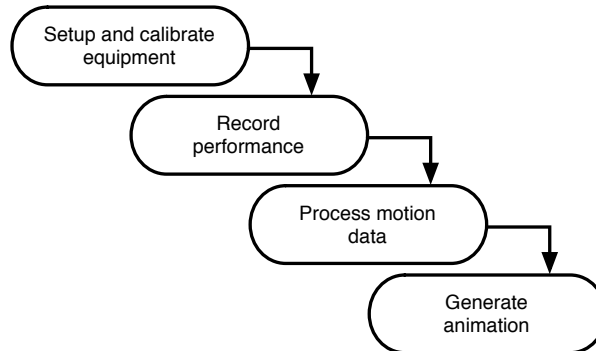# Today

- Motion Capture

Motion Capture

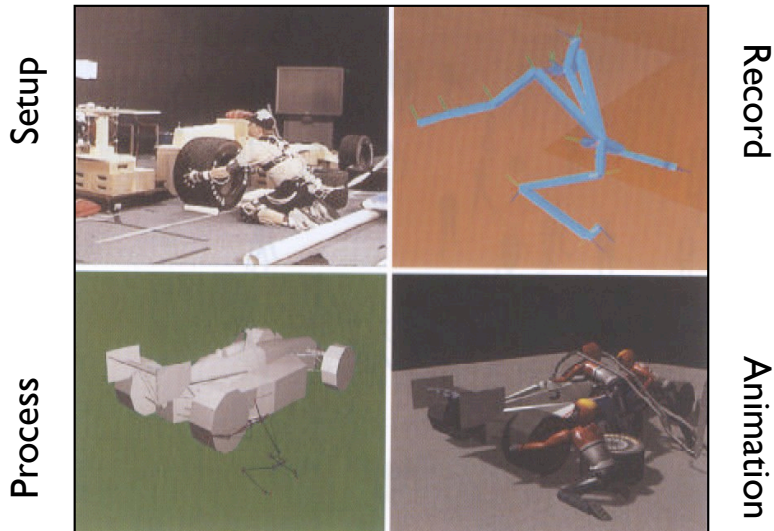○ Record motion from physical objects

○ Use motion to animate virtual objects

Simplified Pipeline:

Setup and calibrate equipment

Record performance

Process motion data

Generate animation

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Basic Pipeline

Setup

Record

Process

Animation

From Rose, *et al.,* 1998

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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

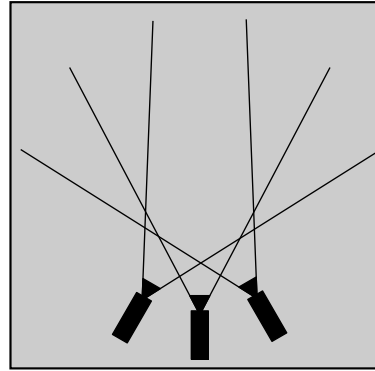Images from Motion Analysis

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
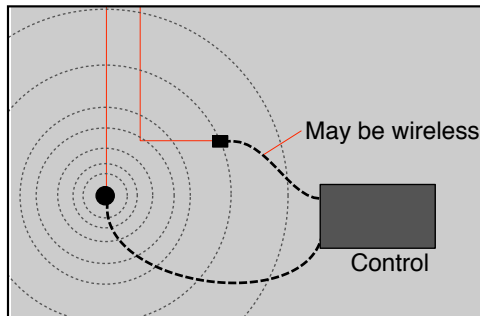 - Number of markers trades off w/ frame rate

Phoenix Technology

Phase Space

Capture Equipment

○ **Magnetic Trackers**

  ○ Transmitter emits field

  ○ Trackers sense field

  ○ Trackers report position and orientation
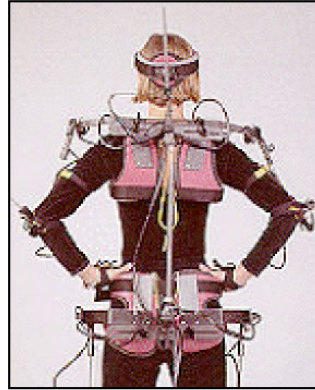

May be wireless

Control

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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

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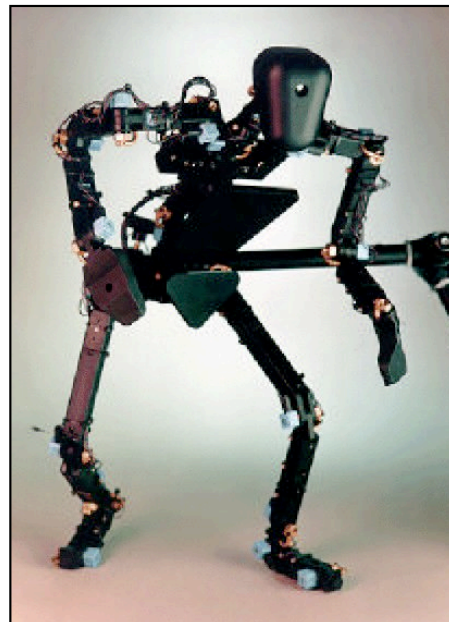# Capture Equipment

○ Electromechanical

Analogus

Capture Equipment

○ Puppets

Digital Image Design

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
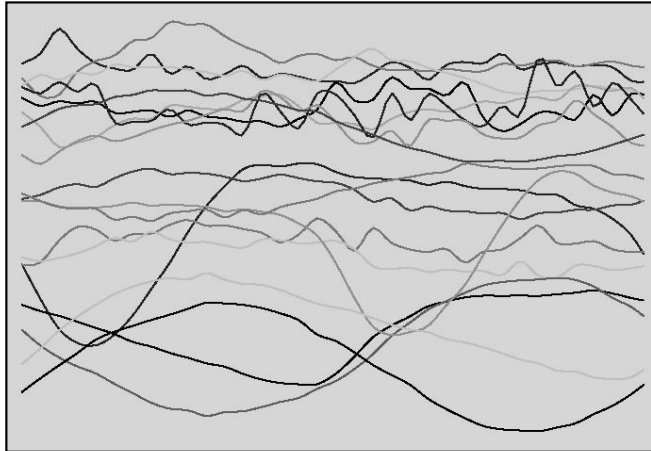 - Similar to digital music and MIDI keyboards

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Manipulating Motion Data

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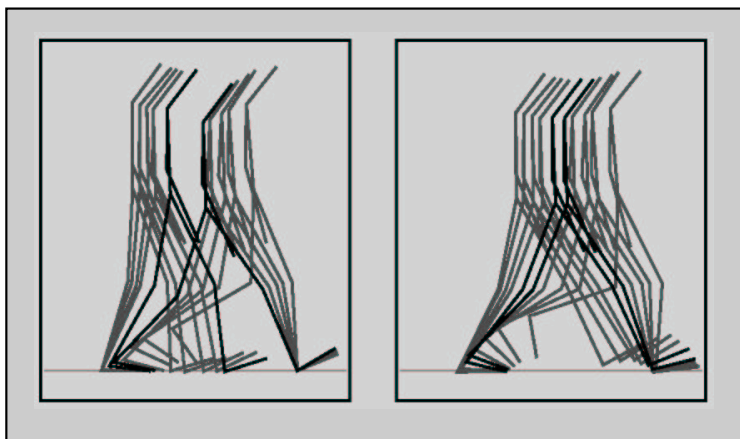 - Retargeting
- Building graphs

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Nature of Motion Data

Subset of motion curves from
captured walking motion.

Adjusting

○ IK on single frames will not work

Gleicher, SIGGRAPH 98
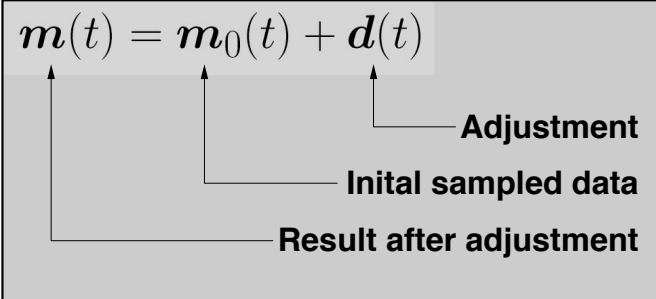
Adjusting

○ Define desired motion function in parts

$$\boldsymbol{m}(t) = \boldsymbol{m}_0(t) + \boldsymbol{d}(t)$$

Adjustment

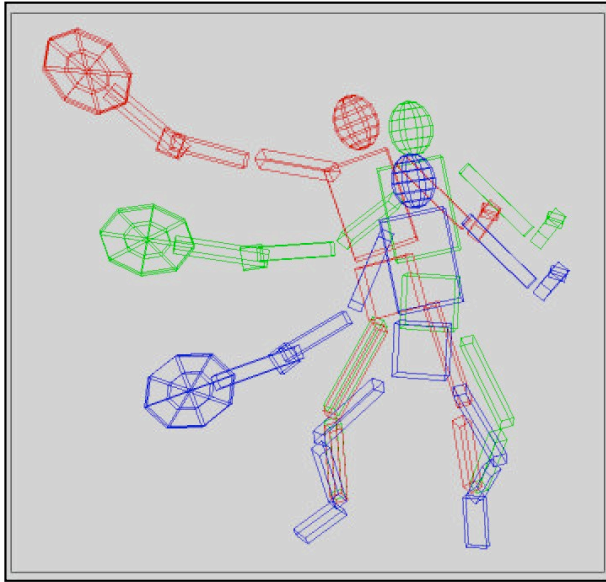**Inital sampled data**

Result after adjustment

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

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Adjusting

Witkin and Popovic SIGGRAPH 95

left hip

original
warped

right hip

What if adjustment periods overlap?

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Blending

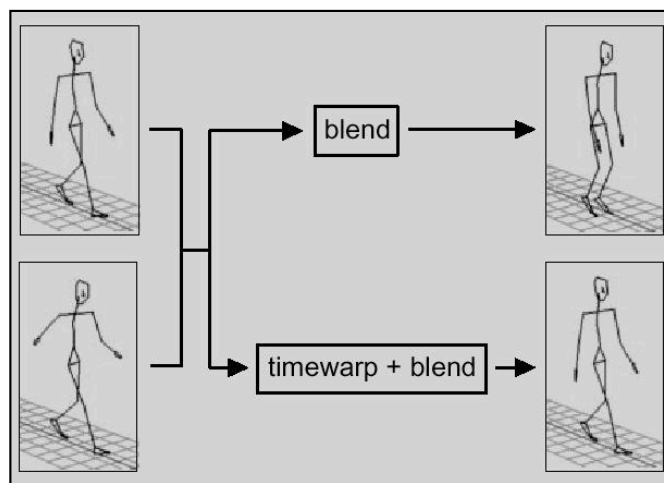- Given two motions make a motion that combines qualities of both

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

- Assume same DOFs

- Assume same parameter mappings

Blending

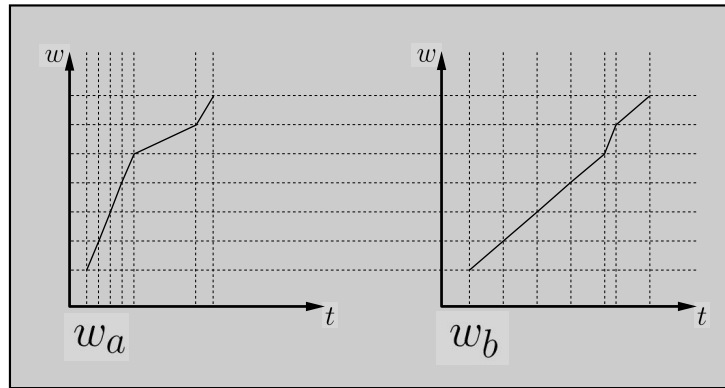- Consider blending *slow-walk* and *fast-walk*

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

Touchdown for Run   Touchdown for Walk

Blend misses ground and floats
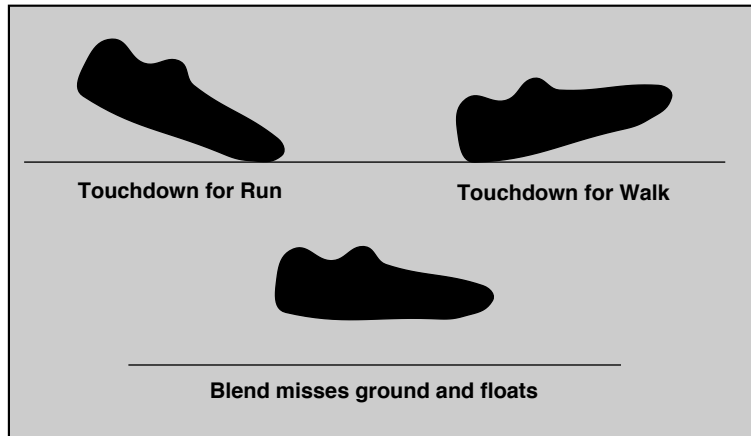
Blending

○ Add explicit constrains to key points

  ○ Enforce with IK over time

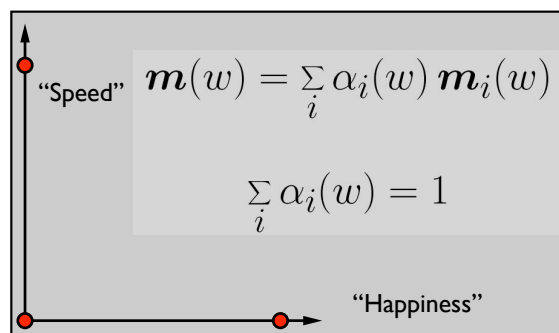Touchdown for Run   Touchdown for Walk
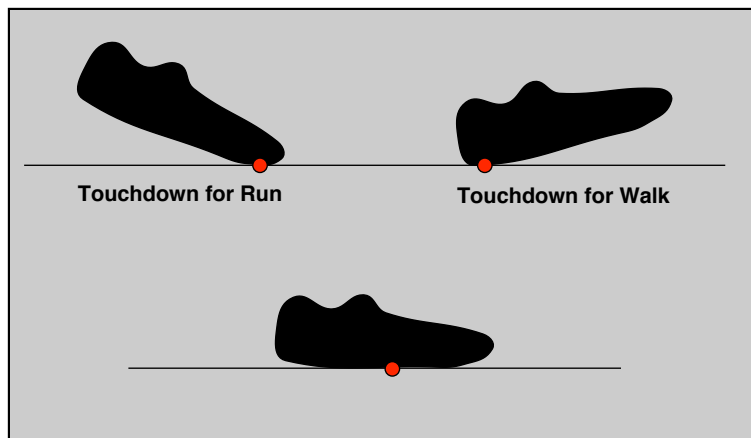
Blending / Adjustment

- 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
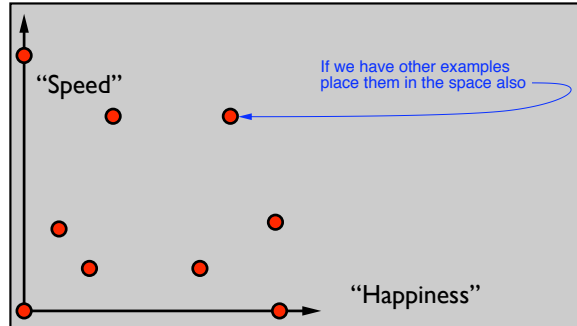
  - Other criteria...

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Multivariate Blending

- Extend blending to multivariate interpolation

"Speed"

$$\boldsymbol{m}(w) = \sum_i \alpha_i(w)\,\boldsymbol{m}_i(w)$$

$$\sum_i \alpha_i(w) = 1$$

"Happiness"

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Multivariate Blending

○ Extend blending to multivariate interpolation

"Speed"

If we have other examples place them in the space also

"Happiness"

Use standard scattered-data interpolation methods

Transitions

○ Transition from one motion to another

w

t

w_b
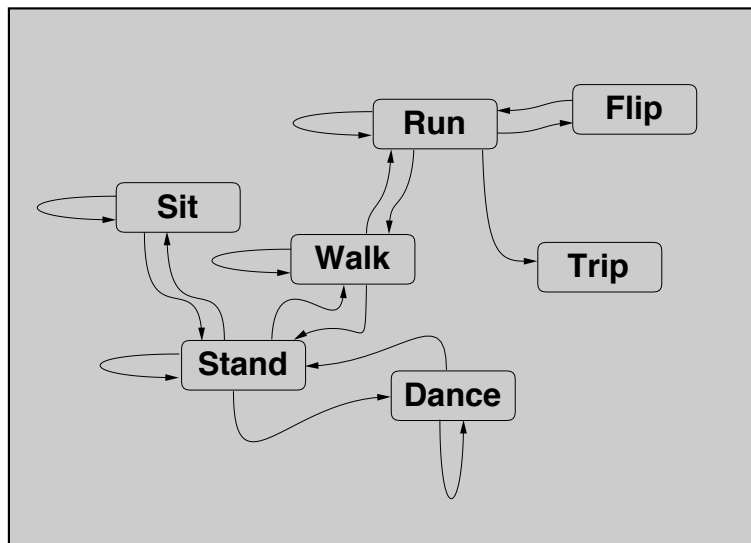
w

w_a

t

Perform blend in overlap region
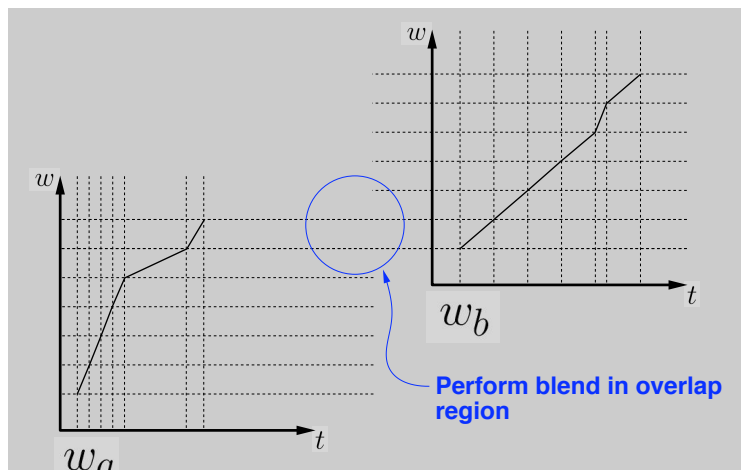
Cyclification

○ Special case of transitioning

○ Both motions are the same

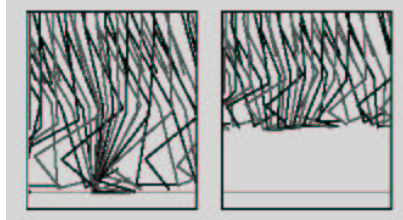○ Need to modify beginning and end of a motion simultaneously

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