Today

- Motion Capture
Motion Capture

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

Simplified Pipeline:

1. Setup and calibrate equipment
2. Record performance
3. Process motion data
4. Generate animation

Basic Pipeline

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
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

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

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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

\[ m(t) = m_0(t) + d(t) \]

- Select adjustment function from “some nice space”
  - Example C2 B-splines
- Spread modification over reasonable period of time
  - User selects support radius
IK uses control points of the B-spline now

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

What if adjustment periods overlap?
Blending

- Given two motions make a motion that combines qualities of both
  \[ m_\alpha(t) = \alpha m_a(t) + (1 - \alpha) m_b(t) \]

- 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

\[ w_a \rightarrow t \] \[ w_b \rightarrow t \]

Normalized time is \( w \)

Blending

- Blend in normalized time

\[ m_\alpha(w) = \alpha m_a(w_a) + (1-\alpha)m_b(w_b) \]

- Blend playback rate

\[ \frac{dt}{dw} = \alpha \frac{dt}{dw_a} + (1-\alpha)\alpha \frac{dt}{dw_b} \]
Blending

- Blending may still break features in original motions

![Blending Diagram 1]

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

![Blending Diagram 2]
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

\[
\mathbf{m}(w) = \sum_i \alpha_i(w) \mathbf{m}_i(w)
\]

\[
\sum_i \alpha_i(w) = 1
\]
Multivariate Blending

- Extend blending to multivariate interpolation

Use standard scattered-data interpolation methods

Transitions

- Transition from one motion to another

Perform blend in overlap region

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Cyclification

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

Transition Graphs

Diagram showing transitions between movements:
- Sit, Stand, Walk, Run, Trip, Dance, Flip

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Motion Graphs

- Hand build motion graphs often used in games
  - Significant amount of work required
  - Limited transitions by design
- Motion graphs can also be built automatically

![Diagram of motion graphs]

Motion Graphs

- Similarity metric
  - Measurement of how similar two frames of motion are
    - Based on joint angles or point positions
    - Must include some measure of velocity
    - Ideally independent of capture setup and skeleton
- Capture a “large” database of motions

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Motion Graphs

- Compute similarity metric between all pairs of frames
  - Maybe expensive
  - Preprocessing step
  - There may be too many good edges

Motion Graphs

- Random walks
  - Start in some part of the graph and randomly make transitions
  - Avoid dead ends
  - Useful for “idling” behaviors
- Transitions
  - Use blending algorithm we discussed
Motion graphs

- Match imposed requirements
  - Start at a particular location
  - End at a particular location
  - Pass through particular pose
  - Can be solved using dynamic programing
- Efficiency issues may require approximate solution
- Notion of “goodness” of a solution

Suggested Reading

- Fourier principles for emotion-based human figure animation, Unuma, Aniyo, 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

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Suggested Reading

- Retargeting motion to new characters, Gleicher, SIGGRAPH 98
- Footskate Cleanup for Motion Capture Editing, Kovar, Schreiner, and Gleicher, SCA 2002.
- Interactive Motion Generation from Examples, Arikan and Forsyth, SIGGRAPH 2002.
- Pushing People Around, Arikan, Forsyth, and O’Brien, unpublished.