Animation by Example Introduction

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Why animate humans?

- Movies
- Television
- Videogames

- Training
- Simulation
- Analysis

Why is this hard?

- People are good at watching people!
- Human appearance is very complex

- People do many things
  - In many ways
- Subtlety matters
- Hard to describe movement
- "Normal" movements aren't interesting

Aspects of the Problem

- "Gross" Body movement

NOT:

- Appearance Models
- Facial animation
- Cloth, clothing, secondary movement
- Hands

These lectures

1. Representation of humans
2. Motion capture processing and editing
3. Concatenative synthesis
4. Parametric synthesis
5. Skinning

Animation Apreciation 101

- Luxo Jr. Pixar, 1986
- Brilliance (Sexy Robot)
  - Robert Abel and Associates, 1985
  - Early motion capture
  - Early computer graphics look (chrome)
- Final Fantasy
  - Square Studios, 2001
  - Realistic, animated, human characters

Why did I show those?

- Motion is rich, expressive, complex
- Hard to describe mathematically

Where's the math problem?

- How do we describe movement mathematically?
  - So we can use it on a computer
- How do we describe the thing that is moving?
  - The "character"

What is the character?

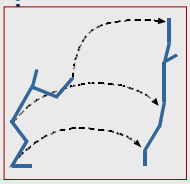
- Way to interpret a configuration
- A vector of parameters
- Some interpretation of these parameters such that a value can be drawn
- Representation

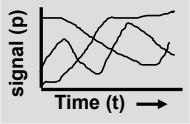
What is a motion ?

- A motion maps times to configurations

$$\mathbf{m}(t) \in \Re \Rightarrow \Re^n$$

- Vector-valued, time-varying signal
- Representation comes from creation
- All we have to do is define the functions!





Why is this so hard?

- We are good at looking at motion!
- Motion is very expressive
  - Mood, activity, personality, …
- But those attributes are subtle
  - What makes a motion sad? Realistic?
- We lack vocabulary
  - Talk about motion with metaphor

Three main ways to make motion

- Create it by hand
- Compute it
- Capture it from a performer
- Animate by example
  - Re use existing motions
  - Editing
  - Synthesis by Example

Creating Motion by Hand: Keyframing

- Skilled animators place "key" poses
  - Computer "in- betweens"
- Requires incredible amounts of talent
  - But can be done extremely well

Verdict: Produces the highest quality results, at a very high cost

Computing Motion: Procedural and Simulation

- Define algorithms to create motions
- Ad-hoc rules, or simulate physics
- Physics provides realism
- But how do you control it?

Verdict: Good for secondary effects, not for characters (yet)

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Motion Capture and Performance Animation

- Use sensors to record a real person
- Get high-degree of realism
  - Which may not be what you want...
- Possibility for real-time performance

Verdict: Good for realistic human motions. Scary to animators.

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Motion Capture Technology: Optical Tracking

- User markers and special cameras
- Tracking + Math



My work

Animation by Example

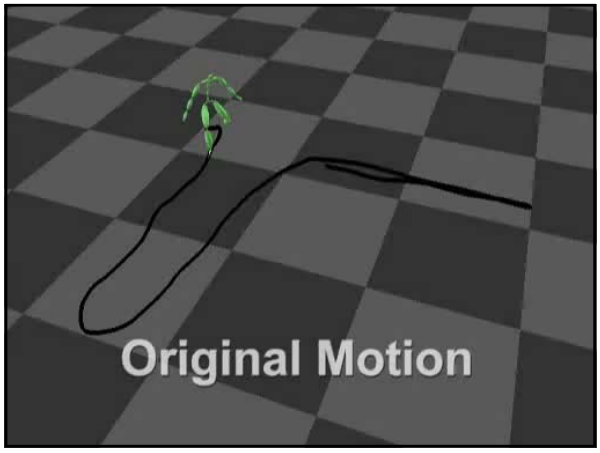
- Good motion is hard to get
- Can't get everything you need
- Need to create motion on the fly

- Re-use existing motions
  - Editing (change an existing motion)
  - Synthesis by example
    - (make a new motion from old ones)

An Example

- How do you make a character ***sneak*** around?

- Start with some captured motion of a person sneaking around
- Synthesize a new motion of a character "sneaking" somewhere else



What did you just see?

- Small amount of example motion
- Examples of what I want
  - Actions
  - Quality
- Character did something different
  - New path
- Character did it the same way
  - Preserves "style" and "quality"

How to make a Character "Sneak"?

- What is sneaking?

- Hard to define mathematically
- Abstract qualities matter
  - Style, mood, realism, …
- Details matter
  - Feet not sliding on the floor
  - Subtle gestures

Idea: Put Clips Together

- New motions from pieces of old ones!

- Good news:
  - Keeps the qualities of the original (with care)
  - Can create long and novel "streams" (keep putting clips together)
- Challenges:
  - How to connect clips?
  - How to decide what clips to connect?

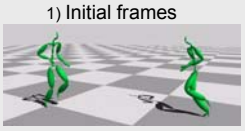
Connecting Clips
Transition Generation

- Transitions between motions can be hard
- Simple method work *sometimes*
  - Blends between aligned motions
  - Cleanup footskate artifacts
  - Just need to know when is "sometime"

What is Similar?

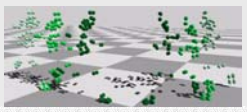
- Factor out invariances and measure

1) Initial frames

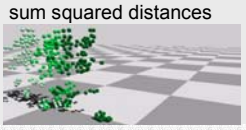


2) Extract windows

3) Convert to point clouds

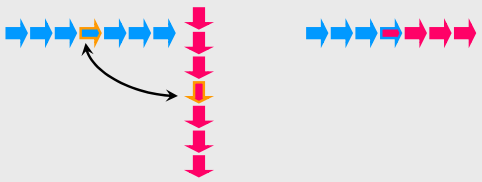


4) Align point clouds and sum squared distances



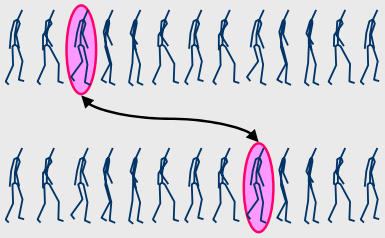
An easy point to miss:
Motions are Made Similar

- "Undo" the differences from invariances when assembling
- Rigidly transform motions to connect



Building a Motion Graph

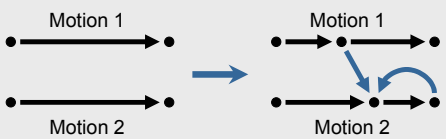
- Find Matching States in Motions



Motion Graphs
Kovar, Gleicher, Pighin '02

Start with a database of motions, each with type and constraint information.

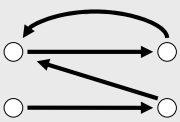
Goal: add transitions at opportune points.



Other Motion Graph-like projects elsewhere
Differ in details, and attention to detail

Motion Graphs

Idea: automatically add transitions within a motion database



Edge = clip

Node = choice point

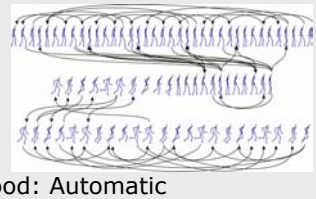
Walk = motion

Quality: restrict transitions

Control: build walks that meet constraints

Automatic Graph Construction

- Find many matches (opportunistic)

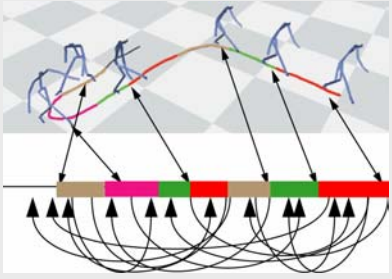


- Good: Automatic
- Good: Lots of choices

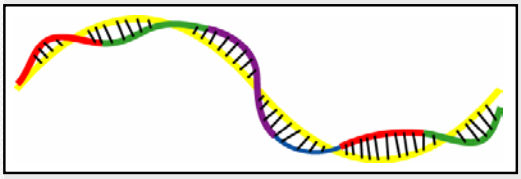
Using a motion graph

- Any walk on the graph is a valid motion
- Generate walks to meet goals
  - Random walks (screen savers)
  - Search to meet constraints
- Other Motion Graph like projects elsewhere
  - Differ in details, and attention to detail

An example:
Building a Motion Graph

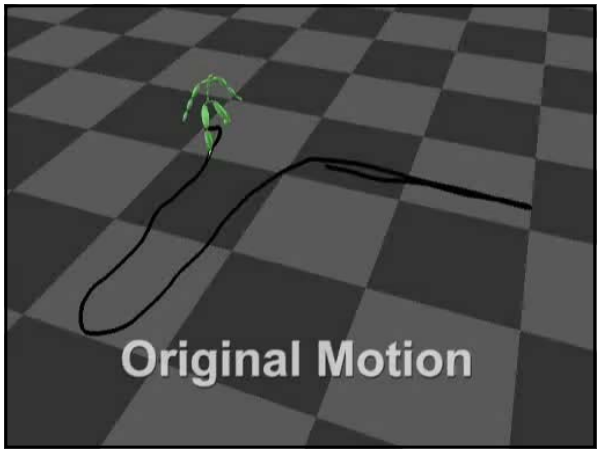


An example:
Using a Motion Graph



- Given a path
- Find a motion that minimizes distance
- Combinatorial optimization

Video: mographs.avi



Why is this good?

- Search the graphs for motions
- Look ahead avoids getting stuck
- Cleanup motions as generated
- Plan "around" missing transitions
- Optimization gets close as possible

Thanks!

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