

Motion Editing with Spacetime Constraints

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Motion Editing with Spacetime Constraints

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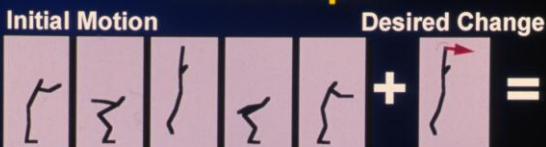
The Goal: Animation for the rest of us!

- Motion is hard to create
- Easier to borrow, steal, buy, ...
 - Goal: libraries of clip motion
- Most motion is not reusable
 - particular character, action, context...
- Edit / adjust it to be something else?

Motion Editing with Spacetime Constraints

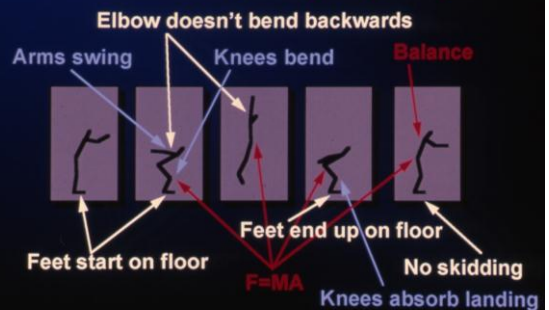
- A model for motion editing:
 - adjust constraints over entire motion
 - solver attempts to preserve original
- Solve for entire new motions:
 - consider all constraints at once
 - emphasize solution speed over quality
- User interface issues:
 - must specify and visualize edits

An Example

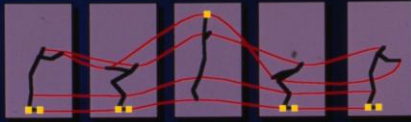


- What is a good answer?
 - Character meets new goal
 - Preserves original
 - Resulting motion is a jump
- Hard to define in general

When is a jump a jump?

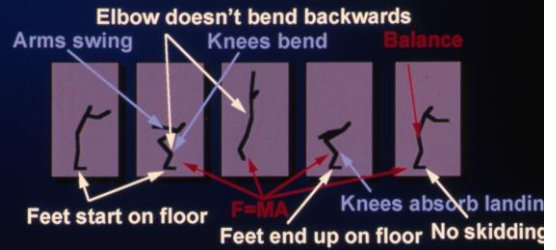


What is Spacetime?



- Consider all constraints simultaneously
- Solve for motions
 - “best” motion that meets constraints
- Physics is just a constraint

When is a jump a jump?



- Geometric Constraints - implement as constraint
- Signal Characteristics - get from signal match

The Questions

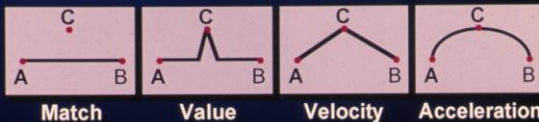
- What constraints?
- What objective function?
- What representation?
- How to solve it?
- How to present it to the user?

Constraints

- Palette of controls for user
- Describe features of motion
 - limitations on character
 - essential constraints on motion
- Nonlinear functions, inequalities
- Implement variational by sampling

The Objective

- Many ways to measure signal difference



- No obvious, general right answer
 - results are non-intuitive
 - choice effects solution difficulty
 - off-load importance with constraints

The Representation: Motion Displacement Maps

- Define $m(t) = m_0(t) + d(t)$
- Search for $d(t)$



- Advantages:
 - good starting point
 - representation independence
 - pick representation for displacement based on desired changes

How to Solve it

We are really re-solving the non-linear constrained optimization problem between each screen refresh!

- Solve a sequence of approximate problems that are easier to solve
- We model as quadratic programs
 - linearize the constraints
 - quadratic objective function
- Line search to use approximation

How to Make it Fast

- Get a fast computer
- Do good computer science
 - sparsity, caching, algorithms, ...
- Forget what's unimportant
 - trade precision for speed
- Constrain the search space
- Differentialness

The User Interface

- Traditional editing issues apply
 - need to make changes on any frame
 - 3D direct manipulation
- Spacetime makes things harder
 - changes can affect the entire motion
 - all constraints can have affect
- How to visualize what happens?

Feedback



Why not Spacetime? (for synthesis)

- Equations are hard to solve
 - local minima
 - stiff objectives
- Quality is hard to define with math
 - energetically? – cautiously?
 - like a kangaroo? – like Mike?
- Actions are not just from principles
 - motions from skill, instinct, personality ...

What to look for in the demos

- All in real time on a Macintosh
- All interaction is direct manipulation
- Up to 5400 constraints (final example)
 - at most a handful are specified by user
- Various display mechanisms
 - cycling, strobing, stream lines, ...
- Initial solutions OK, but usually adjusted
- Video is not designed for the talk (Apology)

Why Spacetime? (for adaptation)

- Equations are hard to solve
 - good starting points
 - easy to solve objectives
- Quality is hard to define with math
 - reduce importance of objectives
 - objectives by demonstration
- Actions are not just from principles
 - get good motion to begin with

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