

# Animation by Adaptation



Michael Gleicher  
Graphics Group

Department of Computer Sciences  
University of Wisconsin – Madison

<http://www.cs.wisc.edu/graphics>

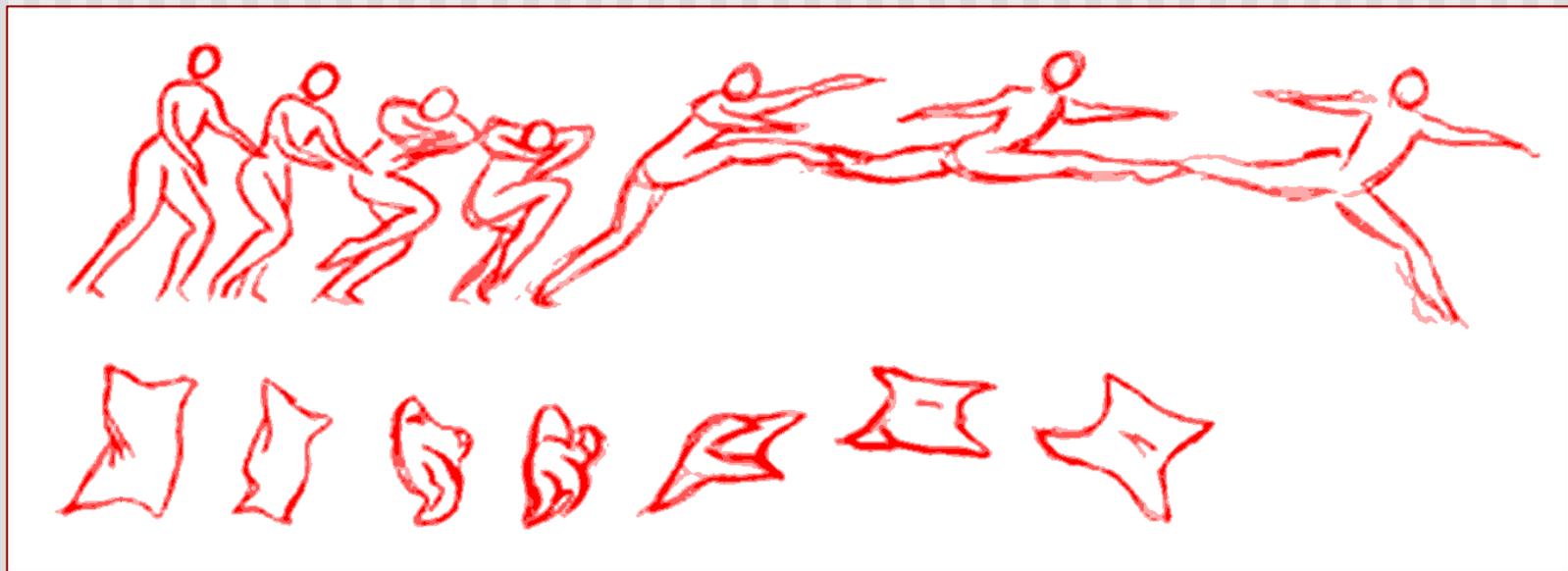
# The Dream: Animation for Everyone!

- ✍ Animation is great
  - ✍ Expressive, appealing, ...
  - ✍ Flexibility and control
- ✍ But it is still the realm of experts
  - ✍ Non-experts need different tools
  - ✍ Not the same as making it easier for experts

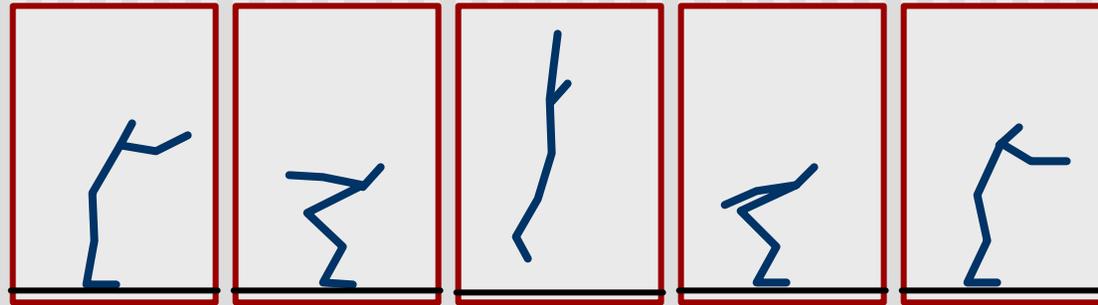


# The Plan...

- ✍ Create animation by re-use
- ✍ Easier to beg, borrow, steal, buy, ...

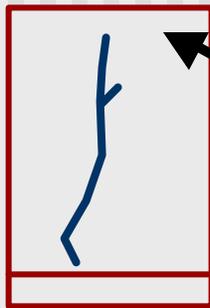


# The Challenge...

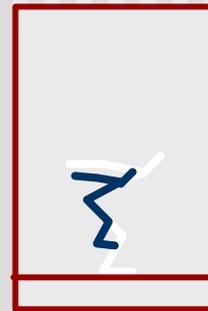


Specific Action

Specific Character



hand is  
not here



different sized  
character  
doesn't fit

***Edit*** motion to  
meet new needs

***Retarget*** motion to  
new character



# The Talk

- ✍ The problem of motion
- ✍ Creating motion
- ✍ Motion editing
- ✍ Our work on motion editing
- ✍ What's next



# Why focus on motion?

- ✍ It is the heart of animation
- ✍ It's the most unique aspect of animation
- ✍ It's the thing most people have the least experience with
- ✍ It's the thing that most interests me

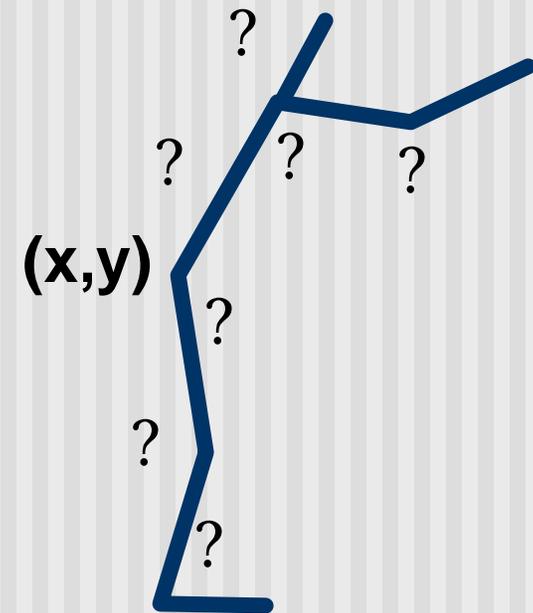


# What is a motion?

- ✍ Animated Character
- ✍ Pose or Configuration
  - ✍ parameters in a vector

$$\mathbf{p} \ ? \ ? \ ^n$$

- ✍ Examples are articulated figures (humans)
  - ✍ trees of rigid links
  - ✍ center + joint angles
  - ✍ nothing specific about methods



$$\mathbf{p} = \{x, y, ??, ??, ??, \dots\}$$

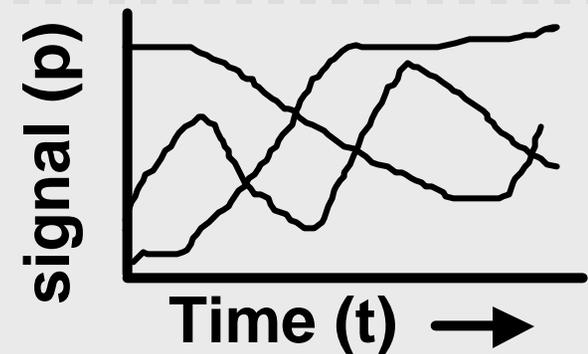
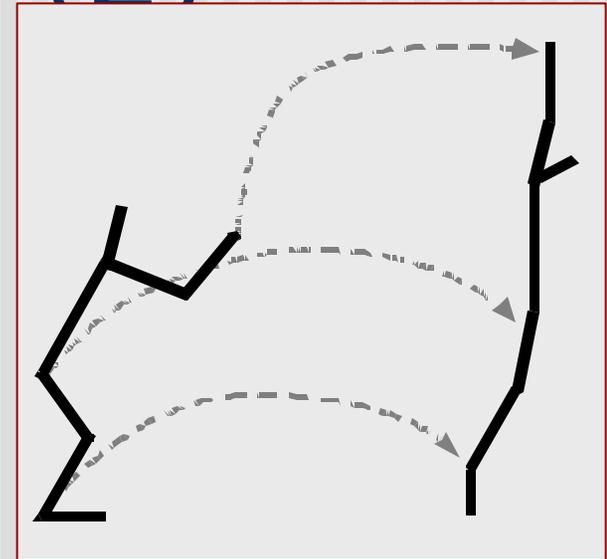


# What is a motion (2)

- ✍ A motion maps times to configurations

$$\mathbf{m}(t) \ ? \ ? \ ? \ ? \ ^n$$

- ✍ Vector-valued, time-varying signal
- ✍ Representation comes from creation
  - ✍ typically interpolation
  - ✍ may not be convenient for editing



# Three main ways to make motion

- ✍ Create it by hand
- ✍ Compute it
- ✍ Capture it from a performer

And increasingly...

- ✍ Re-use an existing motion
  - ✍ (don't make it at all)



# 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)



# Motion Capture and Performance Animation

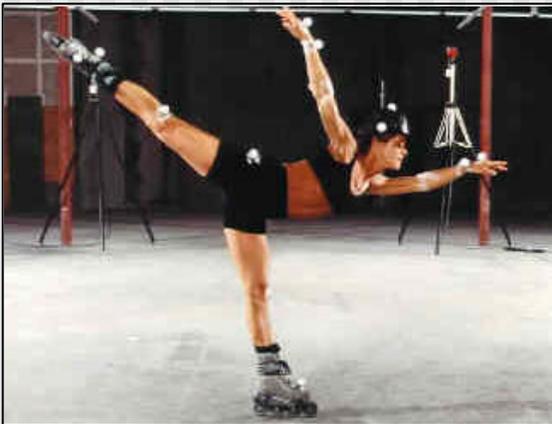
- ✍ Use sensors to record a real person
- ✍ Get high-degree of realism
  - ✍ Which may not be what you want...
- ✍ Possibility for real-time performance

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



# Motion Capture Technology: Optical Tracking

- ✍ User markers and special cameras
- ✍ Tracking + Math



# Motion Capture Technology: Video

- ✍ An interesting and open problem...
- ✍ Limited information
  - ✍ But seemingly enough
- ✍ Problem can be arbitrarily hard
  - ✍ Or easy – if you make assumptions
- ✍ Video is surprisingly bad



# Motion Editing

- ✍ Once you have the motion, now what?
- ✍ Change something about a motion
  - ✍ Character
  - ✍ Environment
  - ✍ Mood
  - ✍ Action
  - ✍ ...



# Transformation Basics

*Change what isn't important, retain what is*

- ✍ Hard to define what is important
  - ✍ high-level properties
  - ✍ motion specific
- ✍ Stick to what's easy to define
  - ✍ geometric constraints
  - ✍ signal characteristics
  - ✍ framework for better metrics later

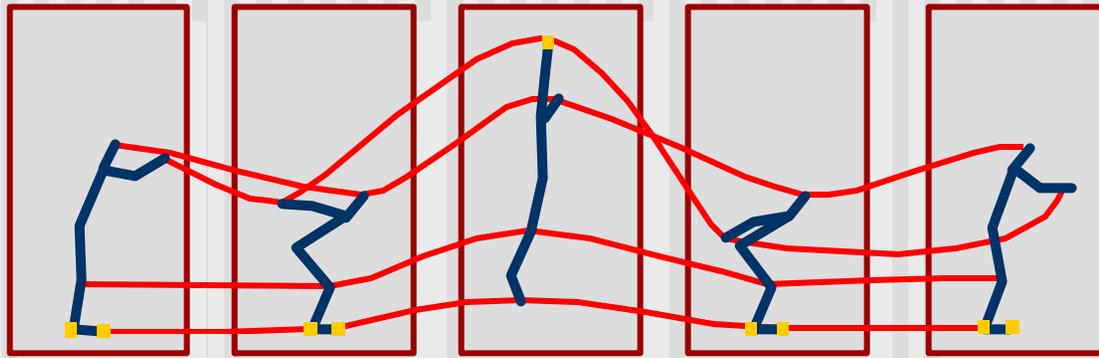


# Transformation as Constrained Optimization

- ✍ Find a motion that...
  1. Meets any specific requests
  2. Keeps any specific characteristics of the original
  3. Is as similar as possible to the original
- ✍ Naturally posed as constrained optimization
  - ✍ subject to meeting the constraints (1 and 2)
  - minimize some objective (3)



# Spacetime Constraints



- ✍ Consider all constraints simultaneously
  - ✍ NOT frame at a time
- ✍ Solve for motions
  - ✍ "best" motion that meets constraints





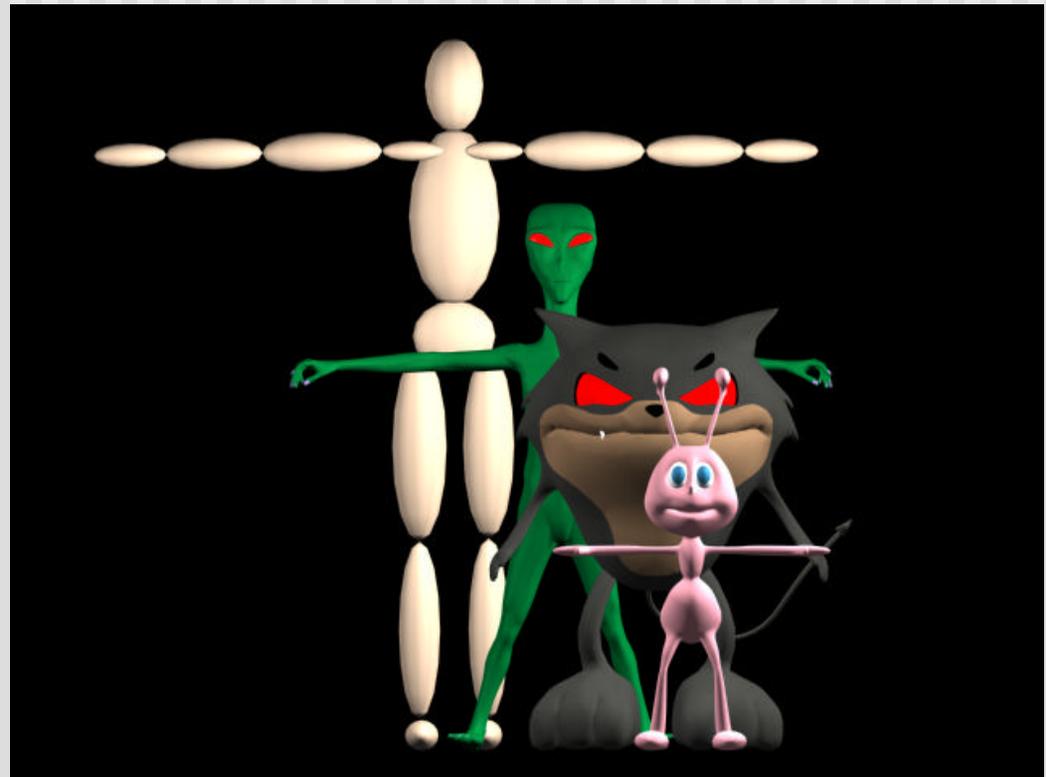
# Basic Idea 2: Frequency Content

- ✍ High frequencies (abrupt changes) are significant and noticeable
- ✍ Altering high-frequencies changes motions
- ✍ Adaptations should avoid disturbing high frequencies



# Retargetting Motion to New Characters

- ✍ Goal: one motion, a cast of characters
- ✍ Focus on similar structure



# Retargetting Recipe

1. Define Constraints



2. Apply to new character



# Retargetting Recipe

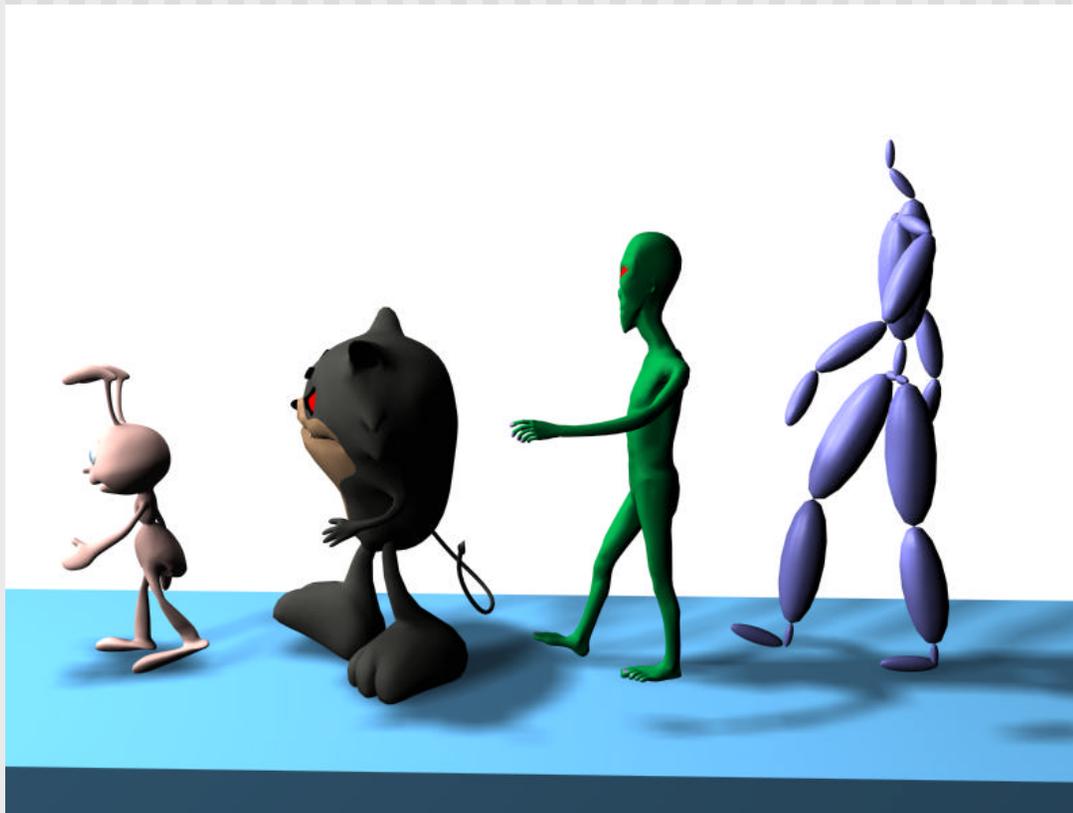
3. Approximate Answer



4. Solve constraints  
(band-limited adaptation)



# Retargetting Results



# Other Editing Tricks

- ✍️ Constraint-based Editing

- ✍️ Motion Path Editing

  - ✍️ Abstract the “path” of a motion

  - ✍️ Alter the path, preserve details of the motion



# Wins and Losses of Spacetime

- ✍ Fast, practical
  - ✍ Linear complexity?
- ✍ Solves real problems
- ✍ Flexibility in:
  - ✍ Spatial Constraints
  - ✍ Objective Functions ?
  - ✍ Temporal Constraints ?
- ✍ Widely applicable
- ✍ Nice results
- ✍ Hard to implement
- ✍ Poor integration
- ✍ Off-line
- ✍ No guarantees
- ✍ Spatial constraints not enforced
- ✍ Flexibility not exploited
- ✍ Rely on constraints



# Is there an alternative?

- ✍ Need to deal with spatial and temporal constraints
- ✍ Don't want the messiness of "whole motion" computation
- ✍ Handle spatial and temporal constraints separately!



# Per-Frame IK + Filter (PFIK+F)

- ✍ IK per frame to solve spatial constraints
  - ✍ But this messes up temporal constraints
- ✍ Filter changes to enforce temporal constraints
  - ✍ But this messes up spatial constraints
- ✍ Iterate until converges, or ...



# PFIK+F vs. Spacetime

- ✍ Fast, practical ✍ Yes! (requires fast IK)
- ✍ Solves real problems ✍
- ✍ Flexibility in: ✍ Yes!
  - ✍ Spatial Constraints
  - ✍ Objective Functions (?) ✍ (depends on IK)
  - ✍ Temporal Constraints (?) ✍ (depends on IK)
- ✍ Widely applicable ✍ (limited, unexplored)
- ✍ Nice results ✍ Yes!
  - ✍ Um, it's a matter of taste, and IK quality



# PFIK+F vs. Spacetime

- ✍ Use standard pieces!
- ✍ Use standard pieces!
- ✍ Choice in which last
- ✍ Solve spatial constraints last
- ✍ Need good IK

- ✍ Hard to implement
- ✍ Poor integration
- ✍ Off-line
- ✍ No guarantees
- ✍ Spatial constraints not enforced
- ✍ Flexibility not exploited
- ✍ Rely on constraints



# My PFIK+F solver

- ✍ Use pieces I have lying around
- ✍ Non-linear optimizing solver for IK
- ✍ FIR linear filters for temporal constraints
- ✍ Propagation of results for temporal coherence



# Downsides of PFIK+F?

- ✍ No global decisions
  - ✍ Doesn't handle "don't cares" as well
  - ✍ Order dependence
  - ✍ No interframe constraints
- ✍ Reliance on quality of IK solver
- ✍ Not necessarily faster (or slower)



# Animation by Adaptation!

- ✍ Motion editing enables libraries of motion
- ✍ As editing evolve, motion re-use becomes more possible
- ✍ Increasingly practical to create motions by adapting old ones



# What's next?

## *Graphics group projects*

- ✍ Video Motion Capture
- ✍ Stylized rendering
- ✍ Virtual Videography
- ✍ User Interface for 3D Applications
- ✍ Visualization



# What's next?

## ***Graphics group projects***

- ✍ Practical issues in Motion Editing
- ✍ Mix-n-match motion
  - ✍ Transitions
  - ✍ Motion Databases
- ✍ Dynamic Applications
- ✍ Automatic Constraint Detection
- ✍ Improved Motion Retargetting



# Thanks!

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