Motion Synthesis By Example

A Tutorial in 3 and 3/2 parts

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Motion Synthesis By Example

Lecture 3: Parametric Graphs

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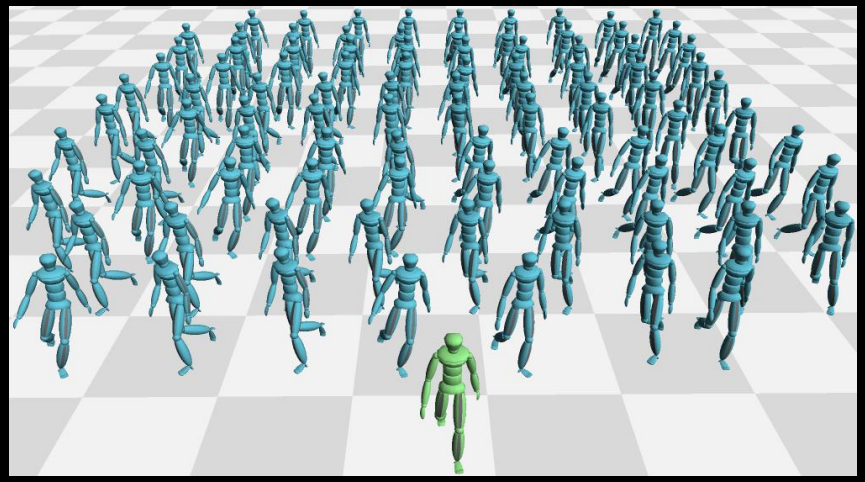
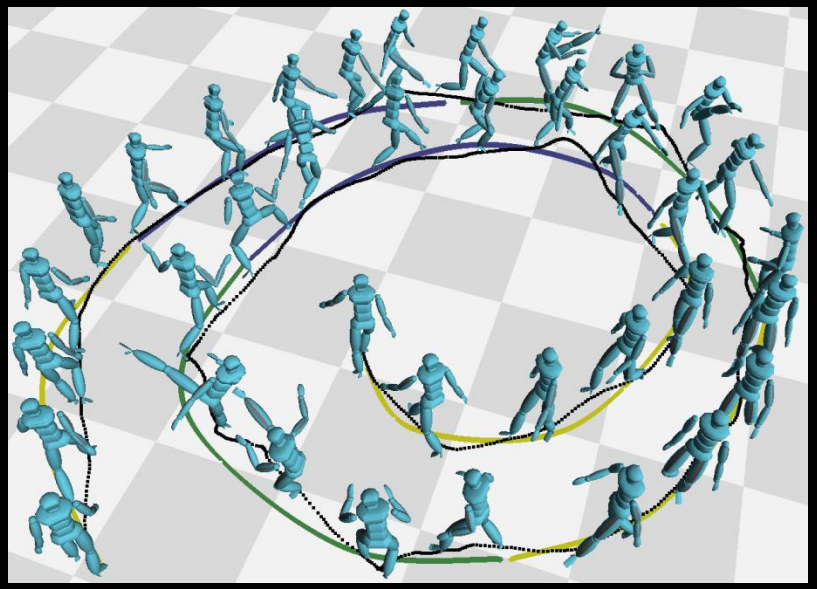
Synthesis By Example

Create what you need from what you have





Have: Lots of Clips

Want: Long Streams
Want: Controllable
Want: Precise/Continuous

A Quick Recap

Motion Graphs

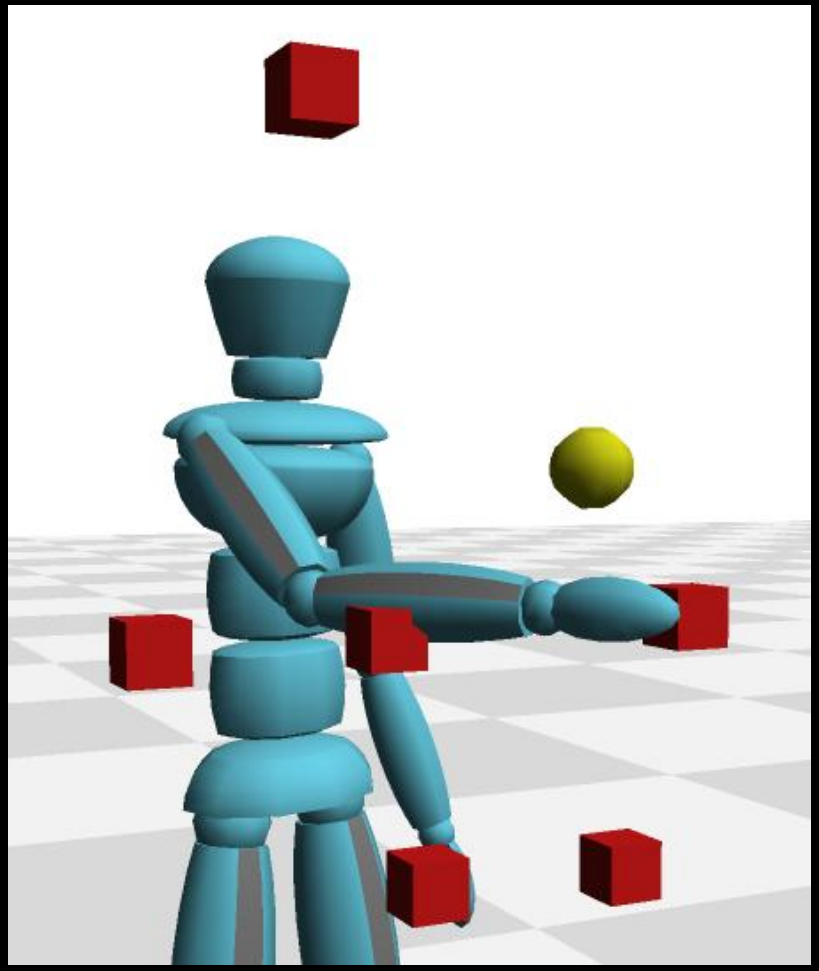
- Assemble long streams of motion from clips
- Use simple connection between clips
  - But only connect when things work
- Search for walks on graphs to create motions
- Discrete choices (time and value)

Think about our goals

- Create long streams 
- Controllable ?
- Precise ✗
- Continuous / Exact ✗
- Responsive ✗

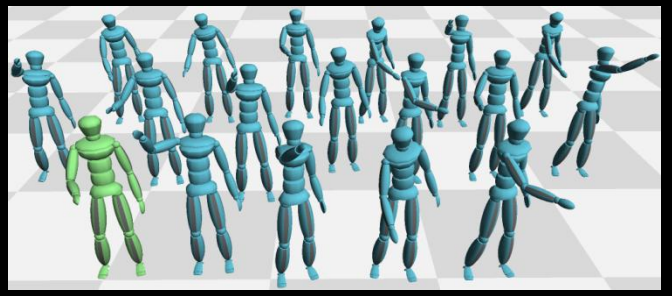
Beyond discrete choices: Parameterization

- How to get a range of movements
- Given only a discrete set of examples
- Result is a motion – this is not just IK

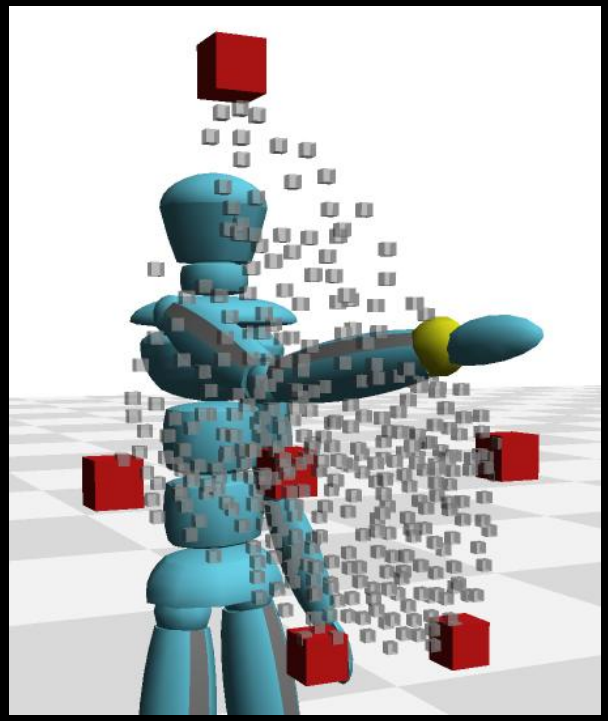


Parameterization by Blending

- Use many examples
- Blend examples to get in-between motions



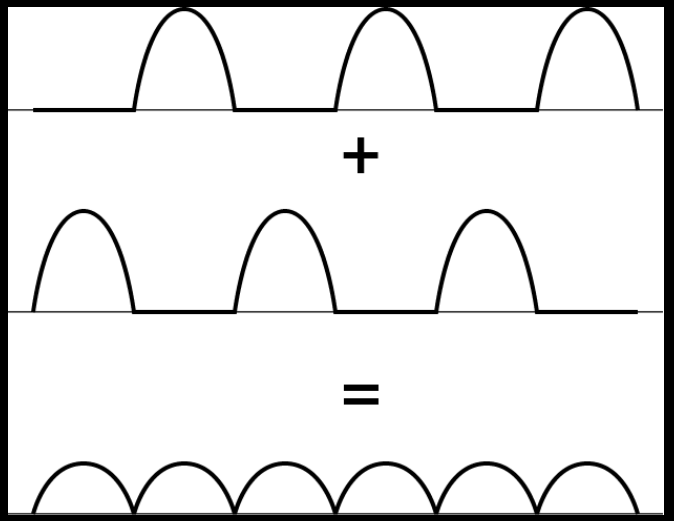
- General
- Gets specific effects
- Gets subtle coordinated effects

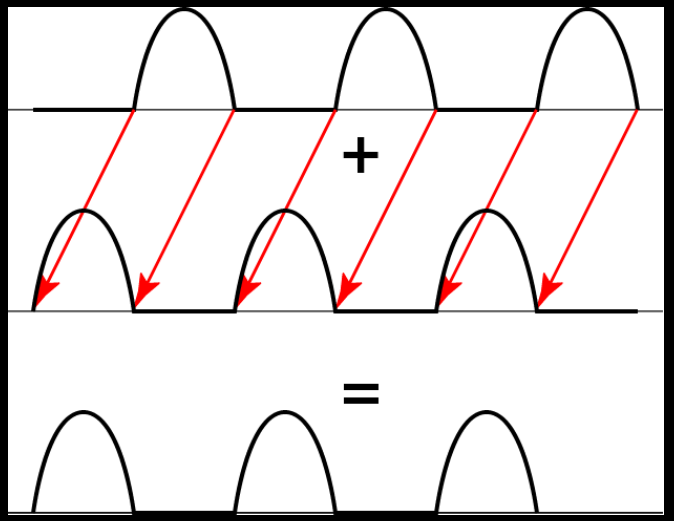


Parameterization by blending

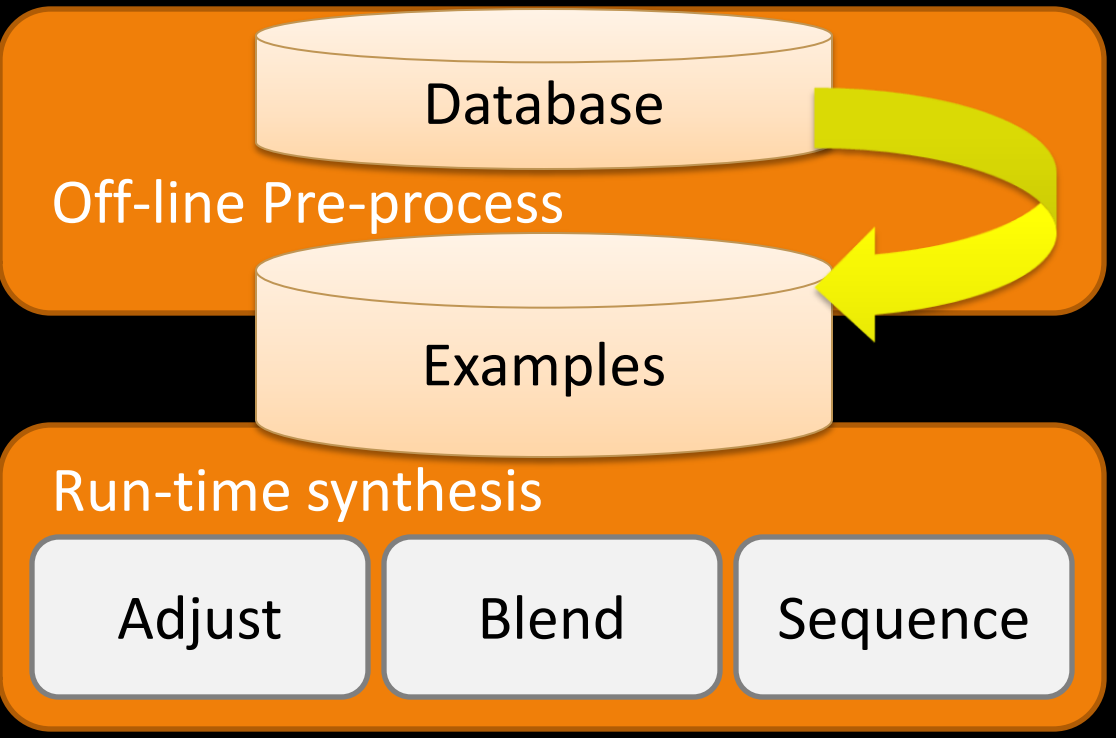
- In research since (at least) Rose et al ’98
- In games for a longer time

- Manual Process
  - Carefully aligned motions
  - Custom crafted parameterizations



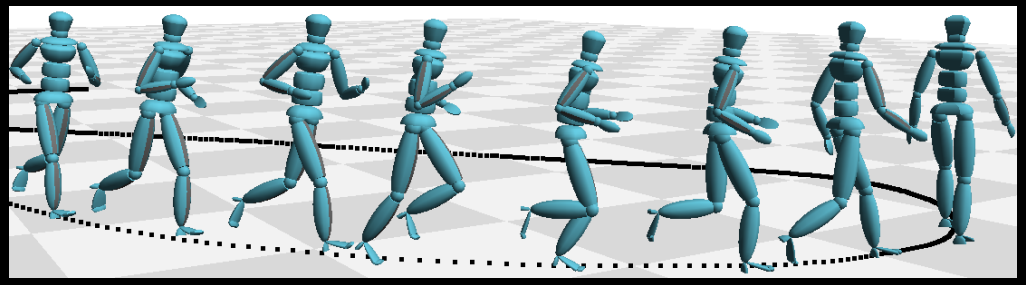


Basic Ideas of Synthesis-By-Example



Preparation:
Extract / process example from source data such that assembly methods work

Assembly:
At run time assemble examples using a few generic (simple) methods

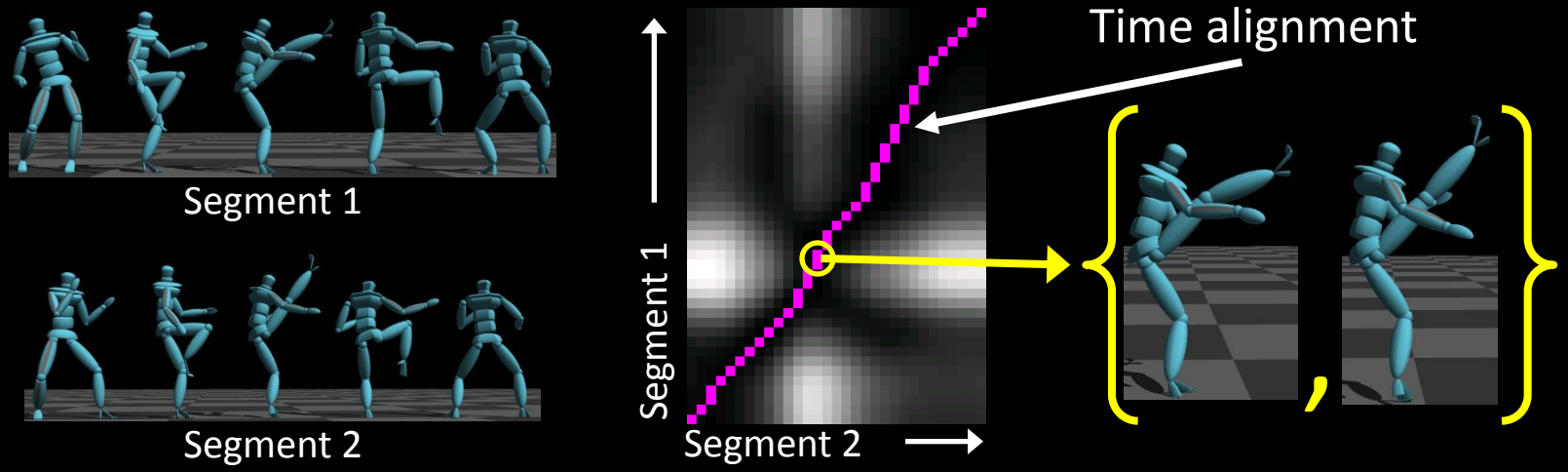


Control:
Choose what is assembled to meet needs (e.g. driven by user, meet goals, …)

SBE in Practice vs. Research
(practice has been doing it longer)

	Practice (real games)	Research
Preparation:	Planning	Automation
	Careful preparation	Automation
	Manual adjustment	Automation
Assembly:	Basic methods	Basic methods
	Tweaks thrown in	Tweaks thrown in
Control:	Carefully crafted&tuned	Parameterization
	Structured data makes problem easier	

Automating Registration



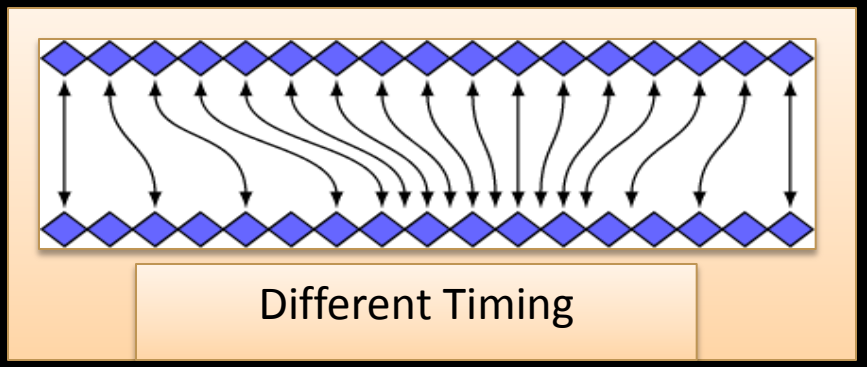
- Apex of kick corresponds
- Even though motions of different lengths

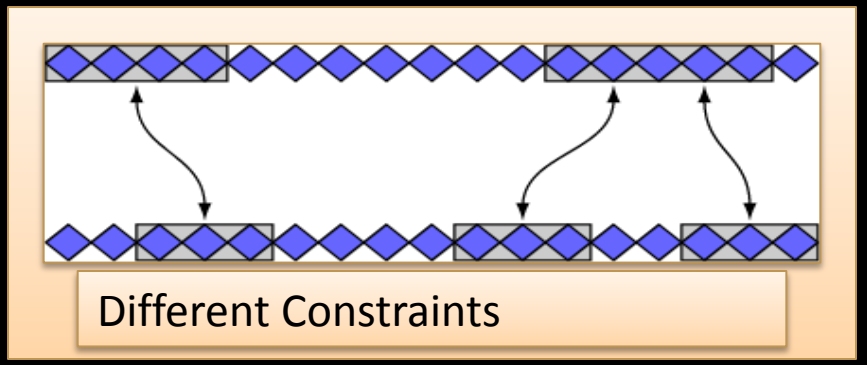
Automating Blending

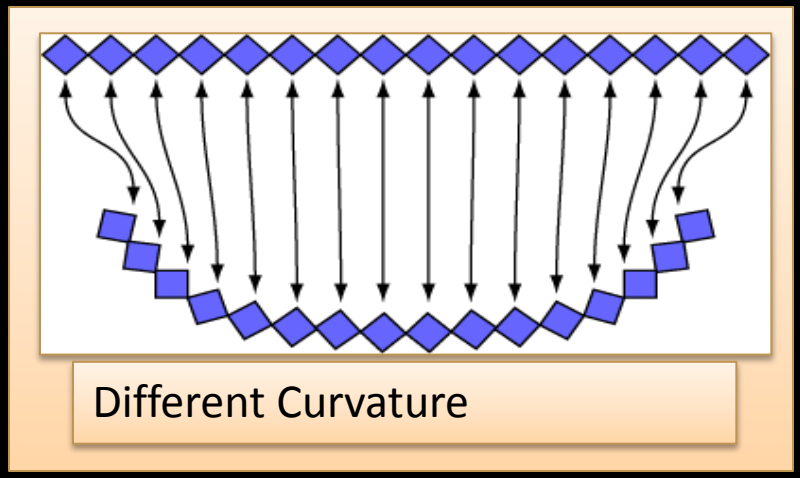
Registration Curves

- Automatic Alignment
  - More detailed time warps
  - Other alignments (curvature, constraints)
- Allowed for more things to be blended

  (not just less effort)





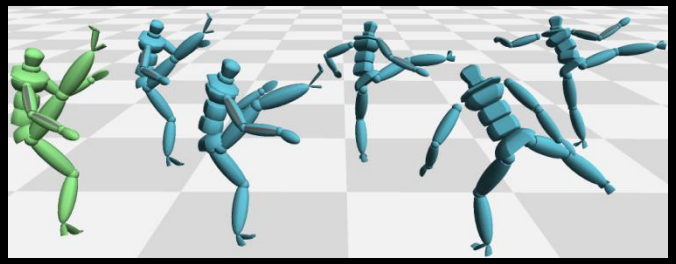


Kovar&Gleicher SCA ‘03

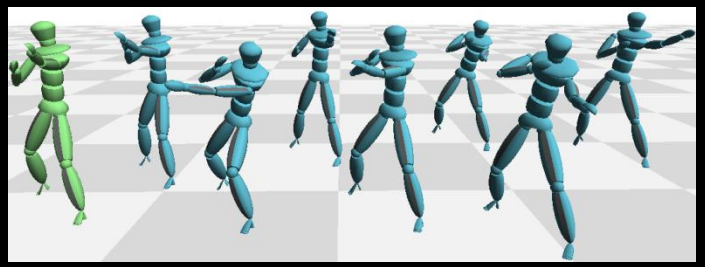
Automatically Finding Examples

Match Webs – Query by Example

- Search database for all motions that can be blended with an example (relatively efficiently)

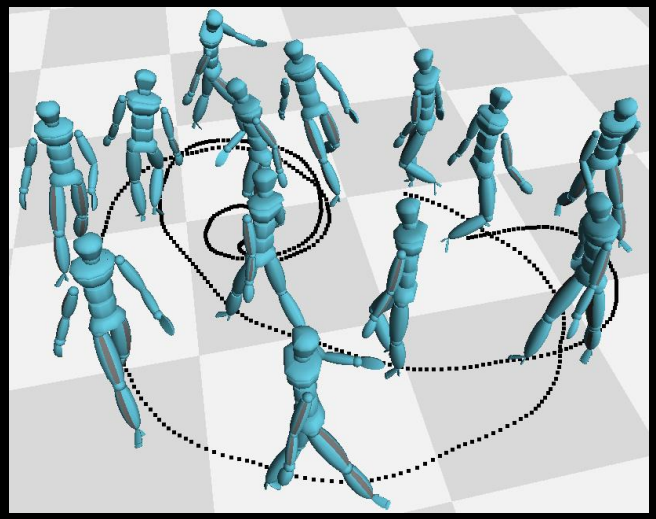


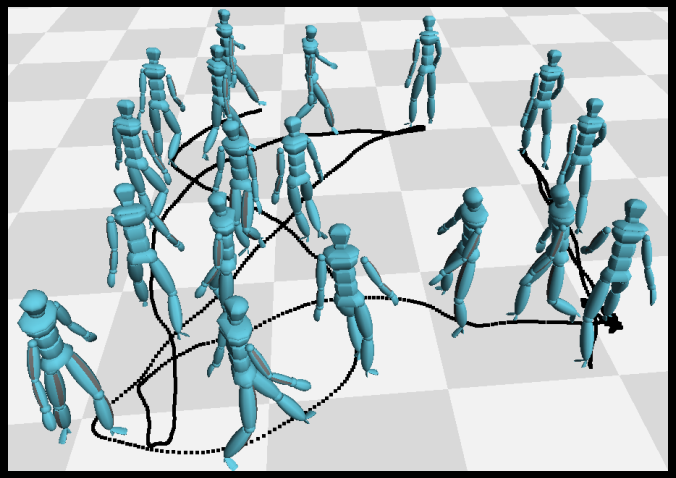
- Finds the registration for each match
- Automatically construct parameterization

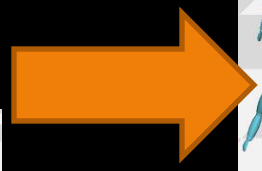


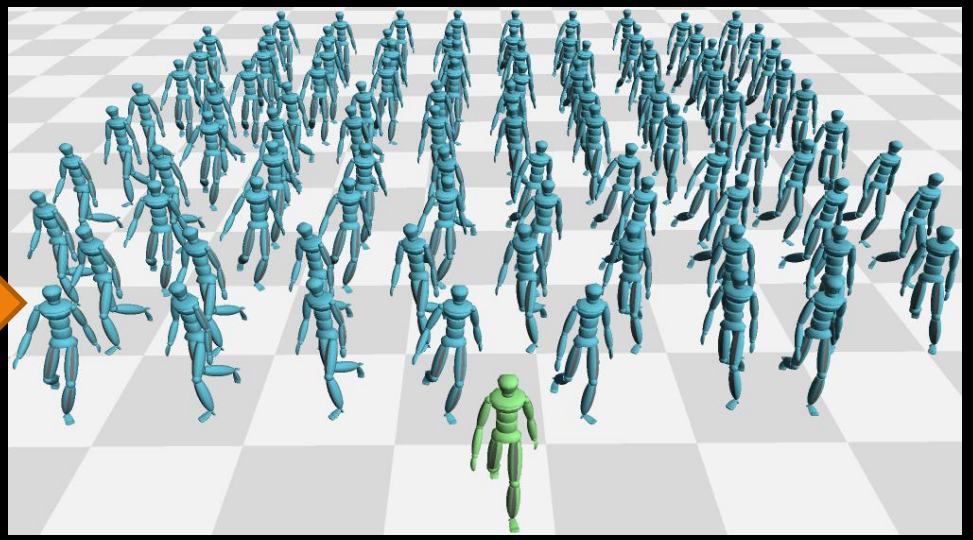
Kovar&Gleicher SIGGRAPH ‘04

Automatically find examples in data

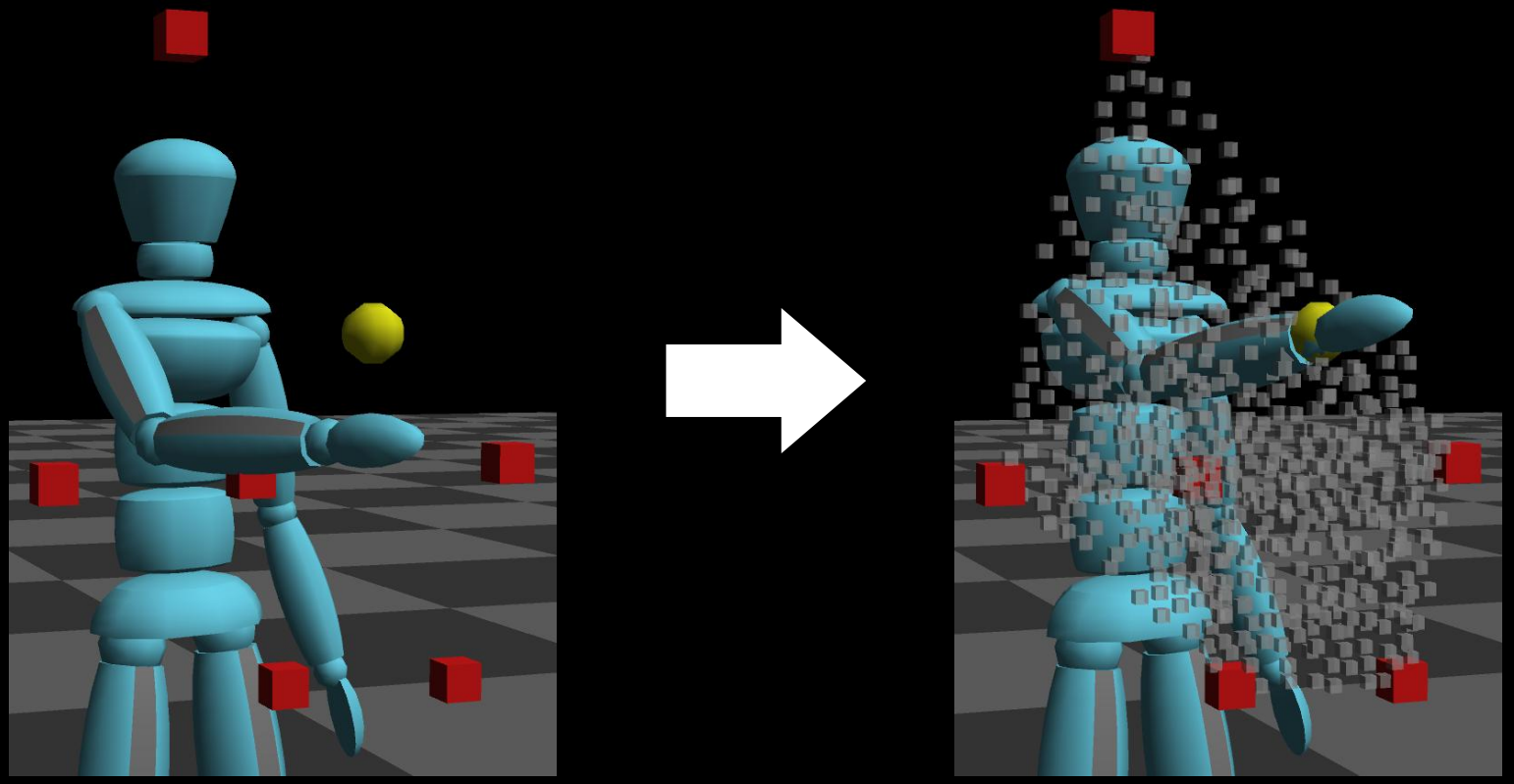






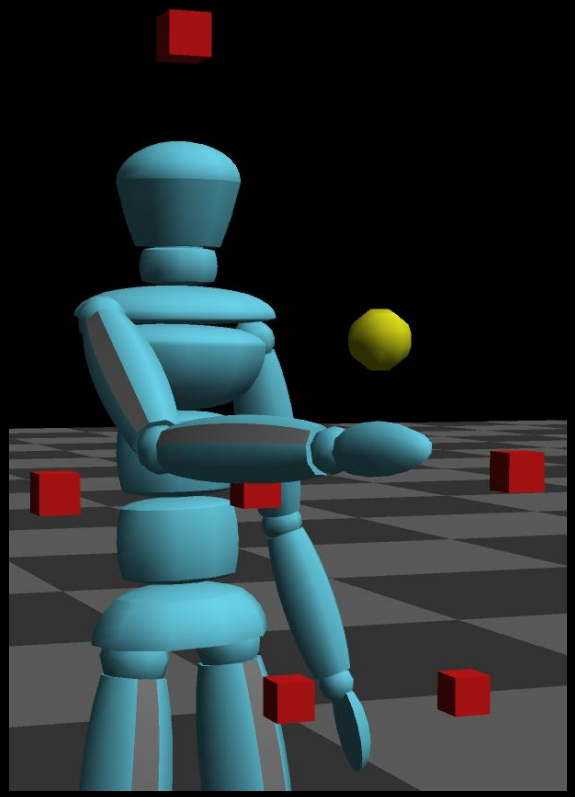


What amounts to blend?



- Automatically map controls to blend weights
- Sampling + Scattered Data Interpolation

What amounts to blend?

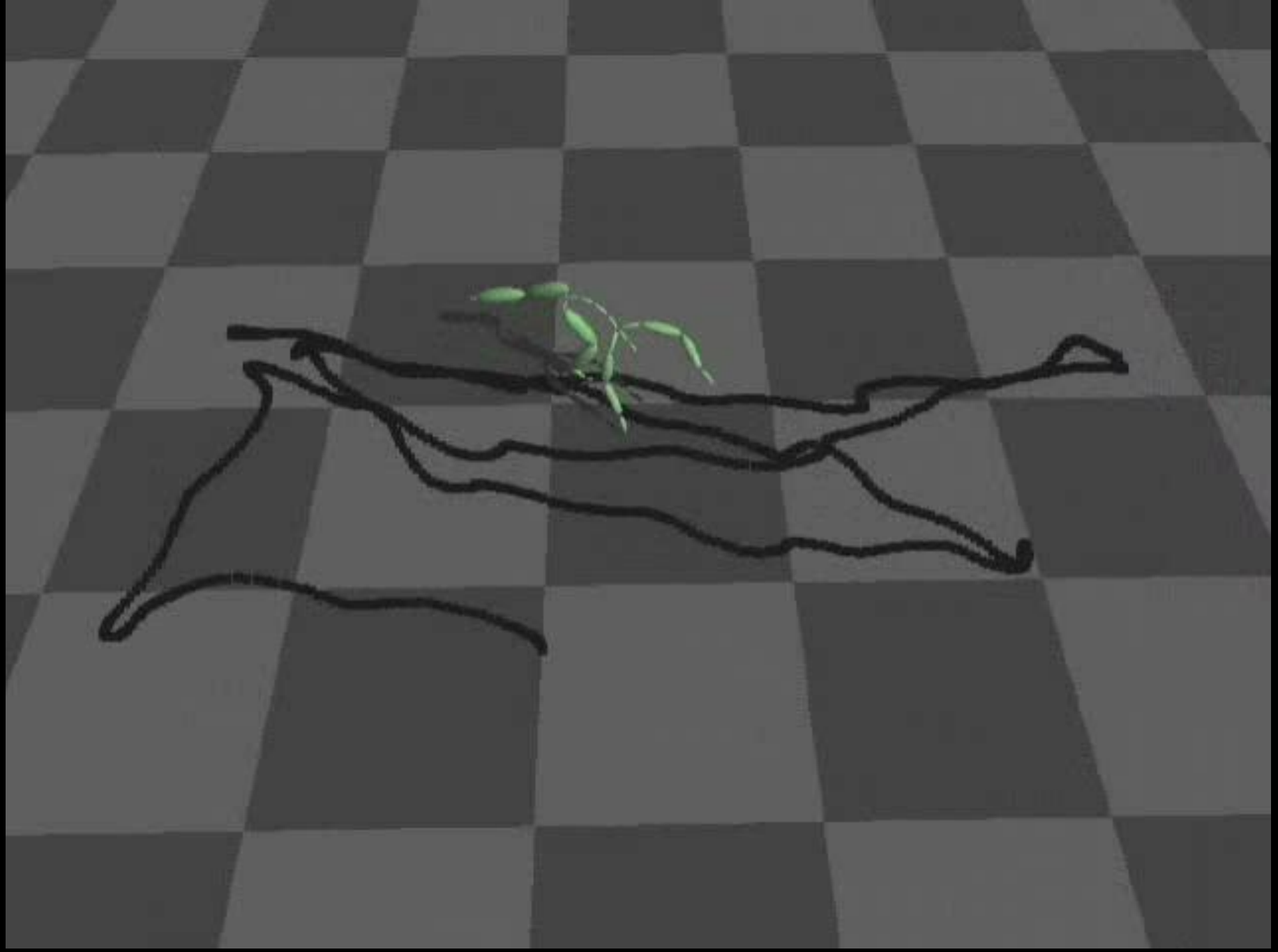


- Continuous control by blend weights
- Not what we want to control
- Irregular or Large Sample Sets
- Non-linear functions

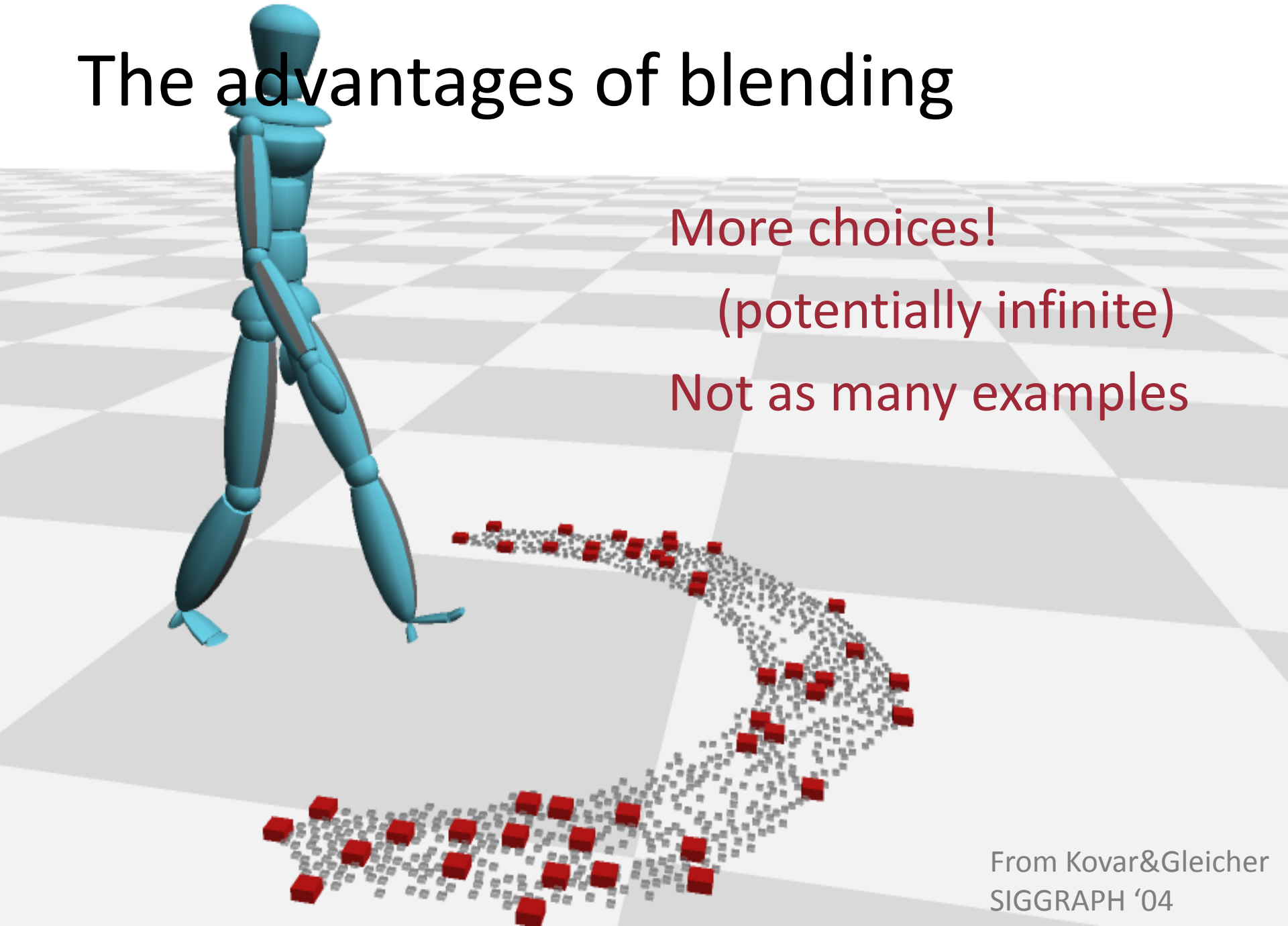
Automation helps blending!

- Reduce amount of labor

- Makes larger example sets practical
- Allows for more complex blends
- More precise control
  - Better parameterizations
- Surprising what examples it can find



The advantages of blending



More choices!

(potentially infinite)

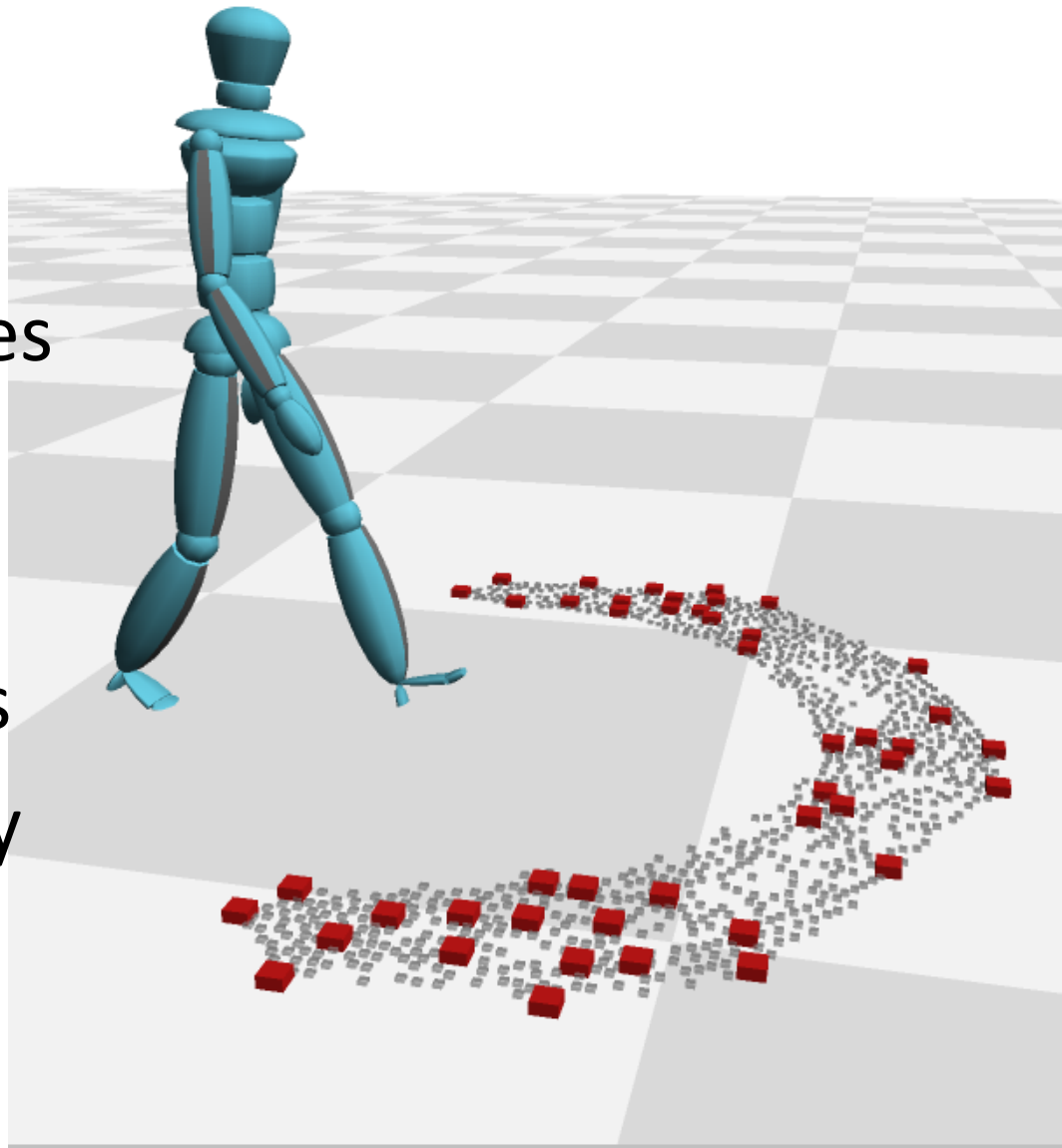
Not as many examples

From Kovar&Gleicher SIGGRAPH ‘04

Automated Parameterization

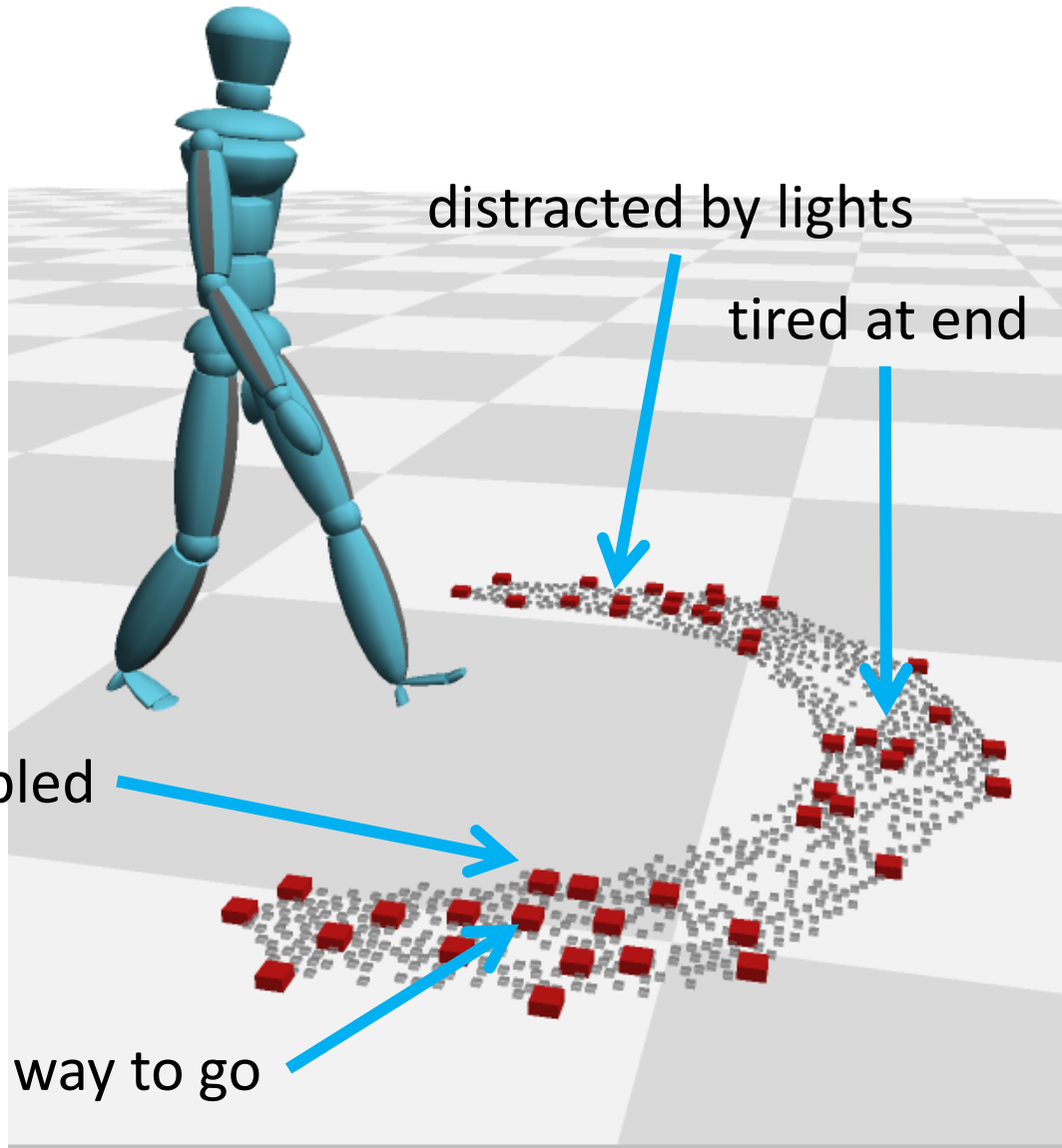
- Build space from all blendable examples
- Blend many examples

- Hard to QA
- Irregular data access
- Unintended diversity



Unintended diversity

- Real data has variability
- Controlled capture reduces it
- An attraction of keyframing



Exploit this diversity?

- Using the diversity in end position already
  - 2D parameterization
- Why not parameterize other things too?
  - Speed
  - Tiredness
  - Focus (or gaze direction)
  - Step height (march / shuffle)
  - …..

The slippery slope of dimensionality…

- A combinatorial explosion!

High dimensional parameter spaces really hard (for blending based approaches)

- Are the dimensions even orthogonal?
- Metrics in the space (for interpolation weights)
- Need enough examples to cover space

How to get consistency?

The character should stay in character

Practice

- Carefully make sure examples are consistent
- Small number of motions for Quality Assurance
- Big attraction of hand animation: closer control

Research

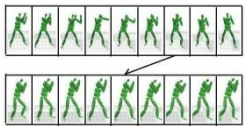
- Unintended diversity in data
  - Different mood, time of day, …
- Harder to find the right thing
- Potential tradeoffs
- Less control over quality

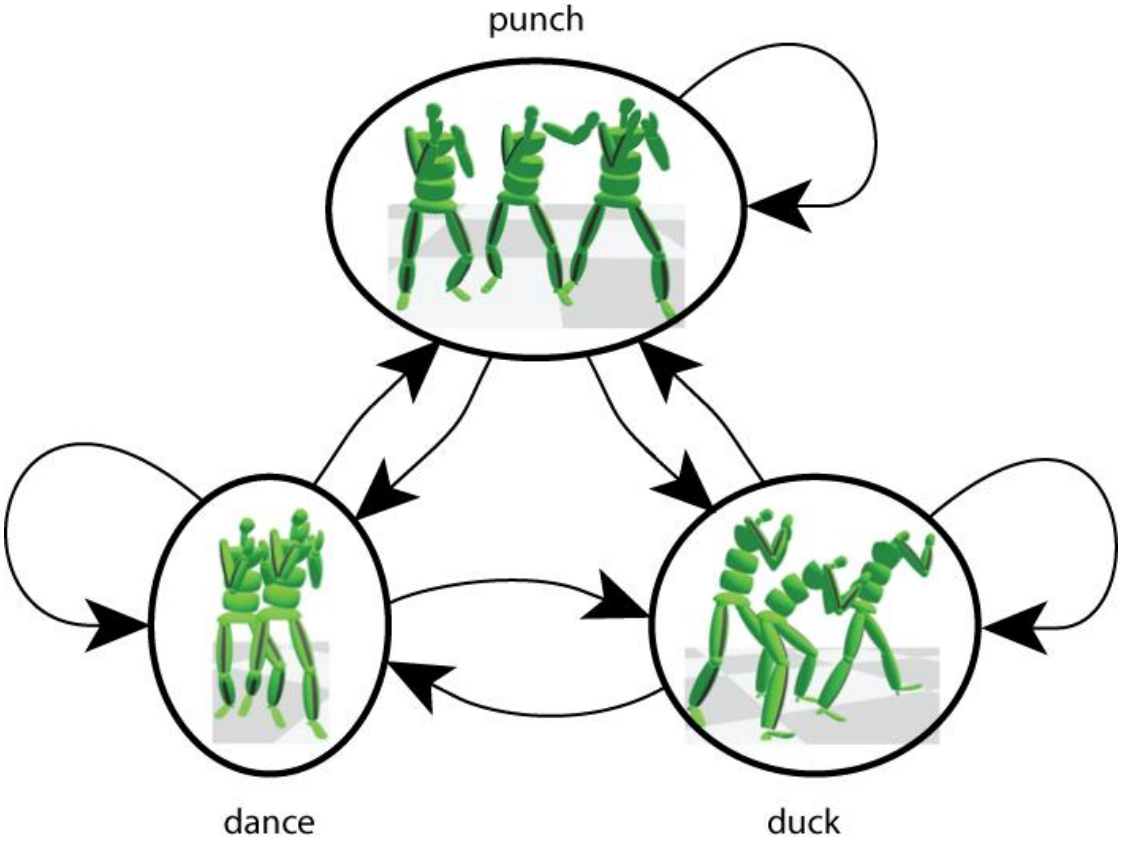
Parametric Motion Graphs

Turning parametric clips into a character

Nodes: Represent  Parametric  Motion Spaces

Edges: Describe How to Transition Between These Spaces





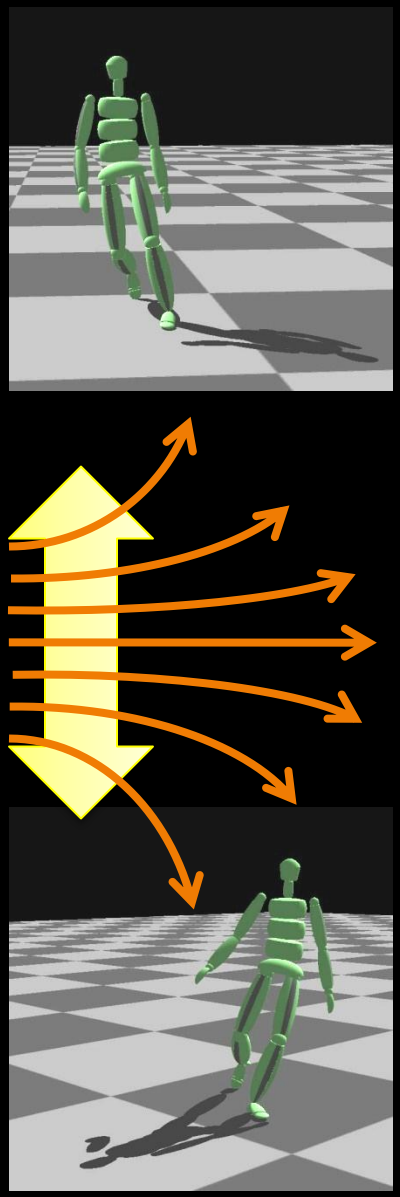
Like everything else, these have been used in games.

Variants have existing for a long time.

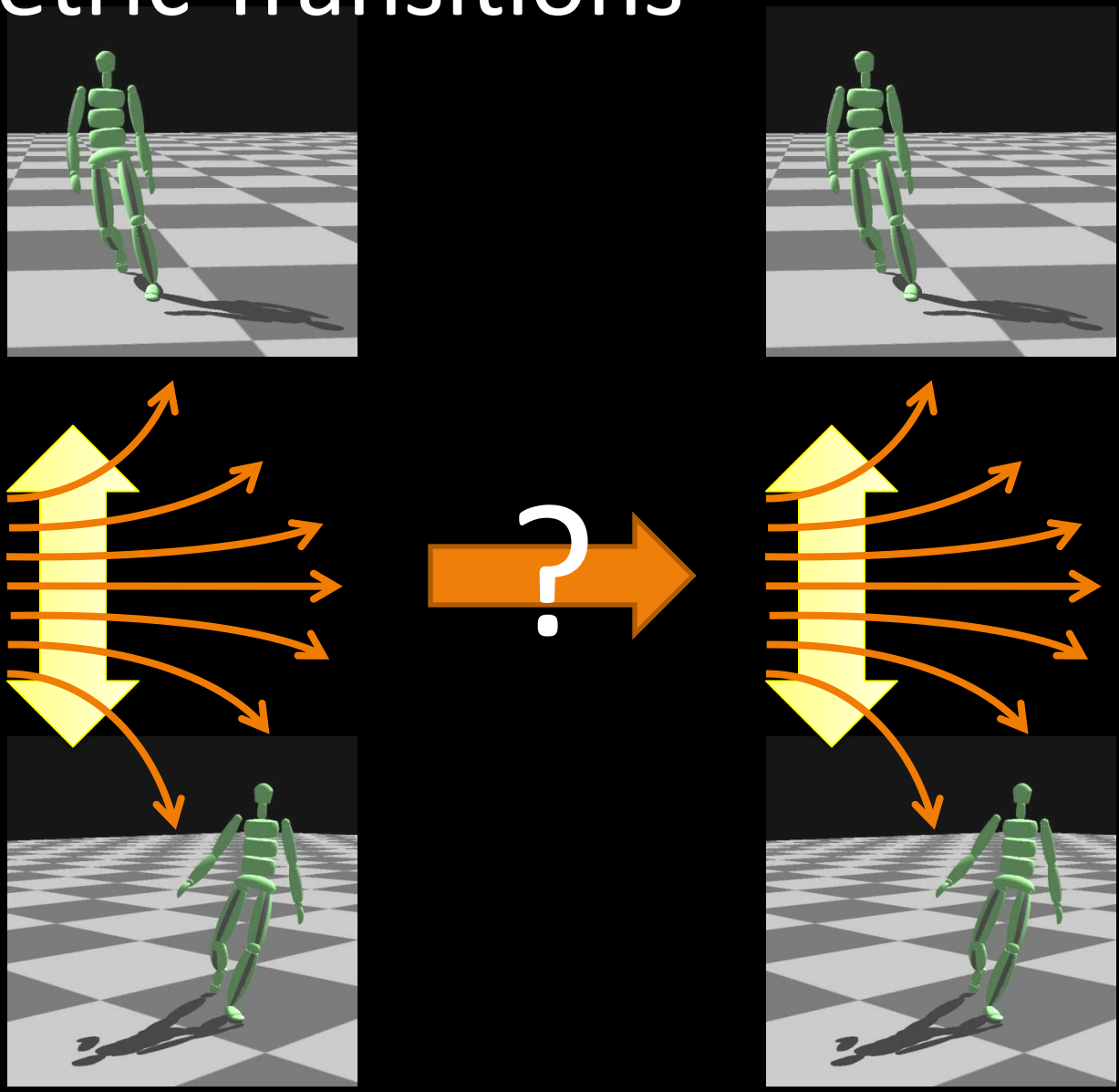
Parametric Graphs

- Each node is a range of motions

- Each node has a range of beginnings and endings



Parametric Transitions

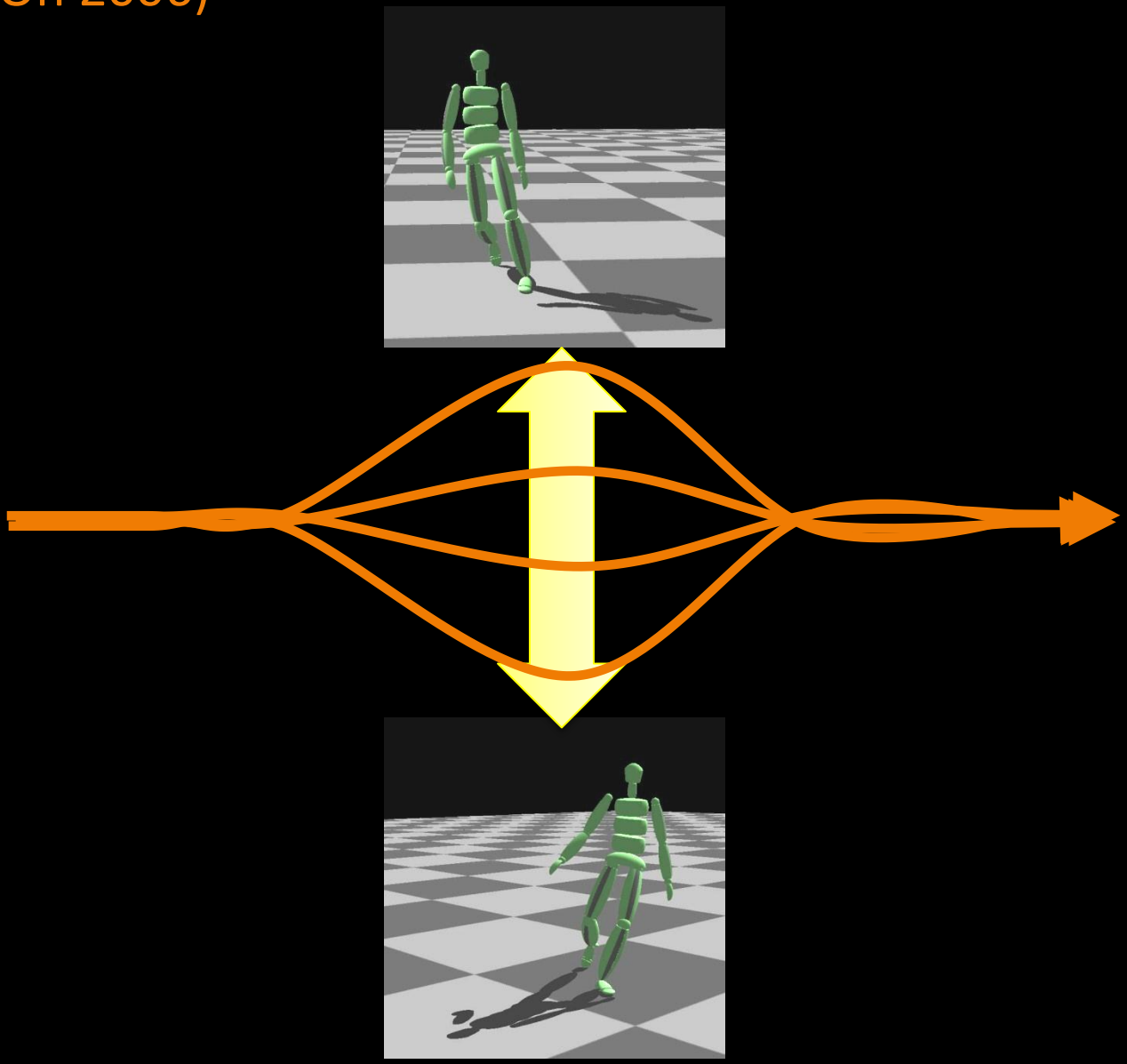


How to make transitions between parametric spaces?

- In practice (?)
  - Build spaces that just work
  - Accept the occasional bad blend
- In research
  - Force common pose (Shin&Oh SCA ’06)
  - Find allowable ranges (Heck&Gleicher I3D ‘07)

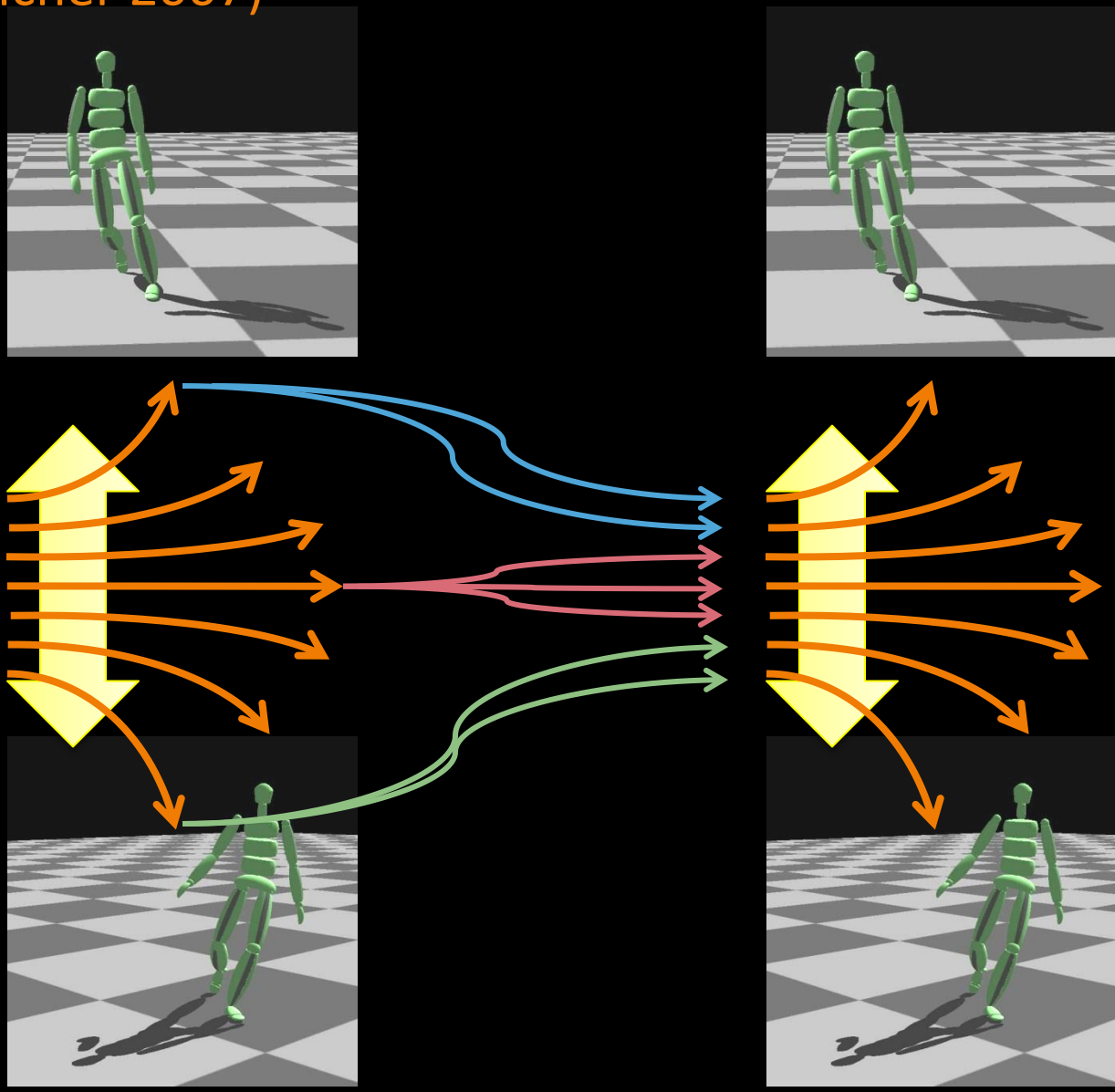
Fat Graphs

(Shin & Oh 2006)



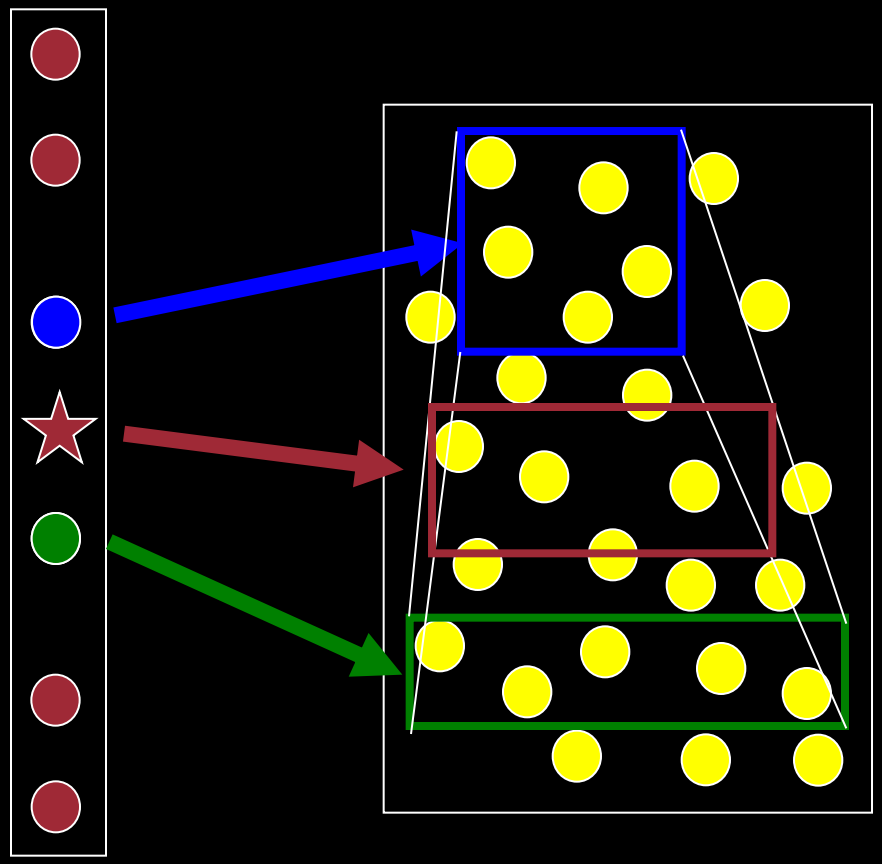
Parametric Transitions

(Heck & Gleicher 2007)



Method: Data Extraction

K-Nearest Neighbor Interpolation

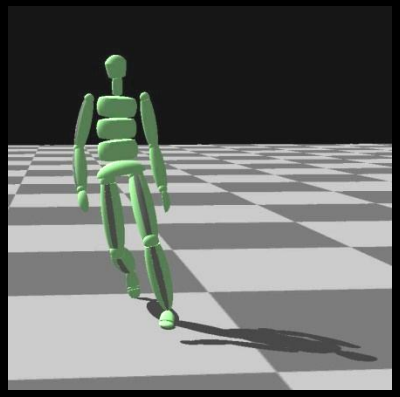


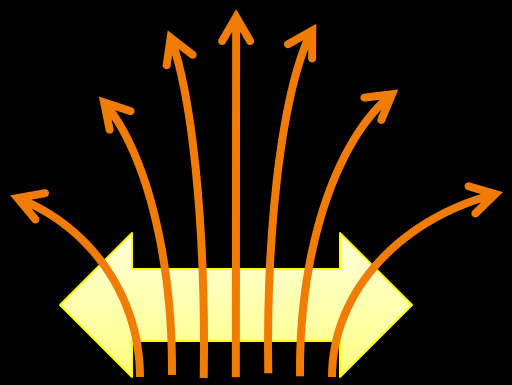

Interactively Controlled Running

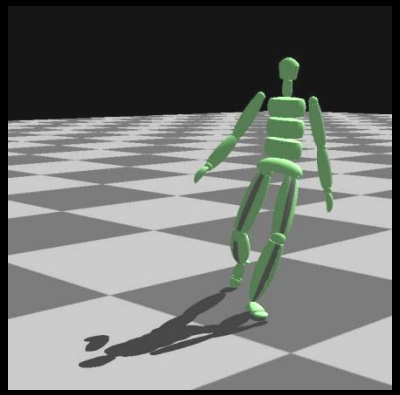
Parametric Graphs Address Scalability

organize motion synthesis

- Independent parametric nodes
  - Automatically determined blends (our stuff)
  - Or anything else you want
- Need transitions between spaces
  - Not all motions connect to all others





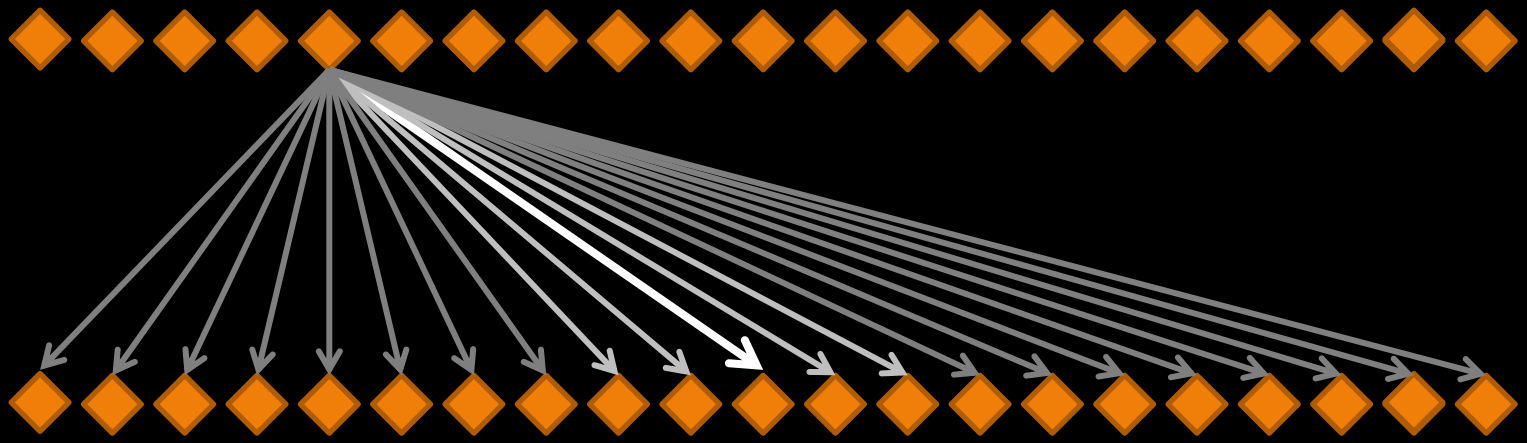


What’s beyond this

The end of graphs?

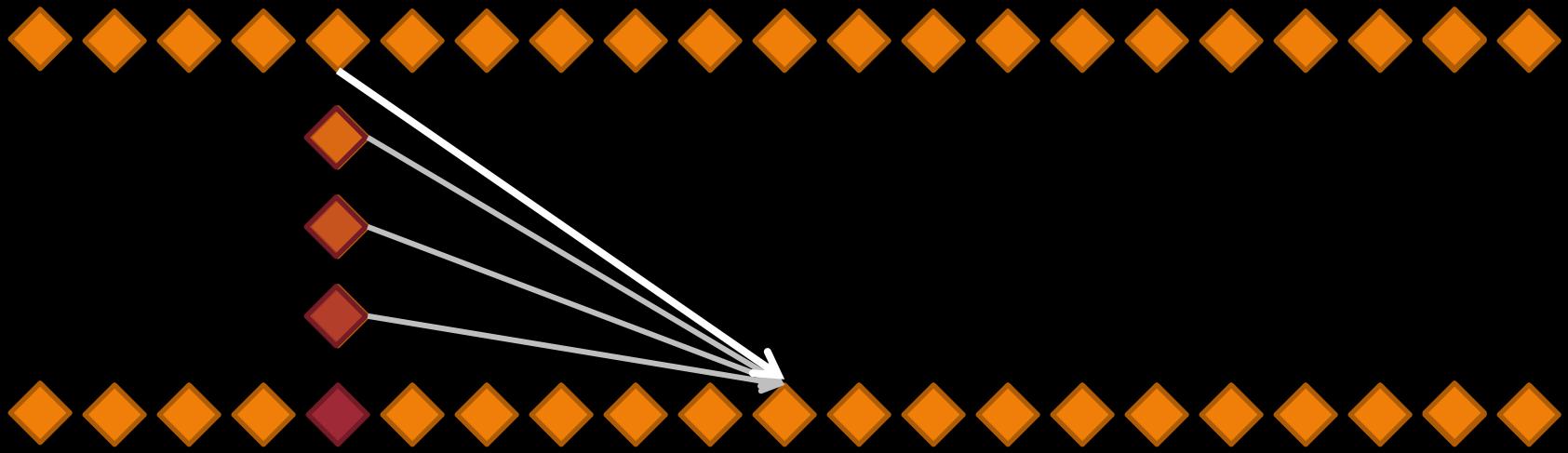
The end of graphs?

Graphs in the limit?



- Consider ALL connections
- Not just good ones
  - Avoid bad transitions, but use if necessary

Graphs in the limit



- Consider poses “in-between” samples
- Any combination of poses could be considered

Beyond Graphs

- Continuous space of poses
  - Entire blend space?
  - Entire pose space?
- Use discrete samples as priors
  - What might be good poses?

- “state” is no longer discrete

No Graph?

Motion Fields for Interactive Character Animation

Yongjoon Lee Kevin Wampler Gilbert Bernstein

Jovan Popović Zoran Popović

SIGGRAPH Asia 2010

I did not do this, but I wish I had

Play video as external file because of codec issue

Why is Synthesis-By-Example so pervasive in games?

Advantage of Synthesis-by-Example

- Actors* are directable (* or good keyframe animators)
  - Can do a range of things a range of ways
  - Consistency in performance
  - Relatively easy to get desired examples

- Get different motions, styles, subtleties
  Without having to model each one
- Easier to scale to diverse repertoire, with acting subtleties, get the directors intent, …

Disadvantage of SBE: No Model!

- Rely on exa
  - Which ma
- Limited ada
  - Simple me
  - Aren't res
- Larger repe
- Scalability?

2 ways to make things better:

1. Use more examples
2. Use examples better

#2 is more likely to scale up
Lessons of #1 may tell us something

Where does motion come from?

Two Approaches

Model-Bas **e**

- Generat tions algorith a
- Craft m gorithms

- Motion y comes by cleve a

- Develop models per motion
- Have a motion model
  - Generate more motion

- No per-motion models
- No motion model
  - Limited adaptability

Approach 2 ½:
Use examples to derive models

Does this get the best (or worst) of both?

Thanks

- The students&collaborators who did the work
  - Lucas Kovar (motion graphs, registration curves, families, …)
  - Rachel (Heck) Rose (parametric graphs, …)
  - Mankyu Sung (crowd simulation)
  - Hyun Joon Shin (snap-together math, physics touchup)
- The rest of our group
- The people who supported us financially
  - Original research supported by NSF, UW Grad School
- The people who gave us data and challenges
  - House of Moves / Vicon (Taylor Wilson), EA, Demian Gordon, Rockstar Vienna, (and a whole lot of others)

- You – for listening