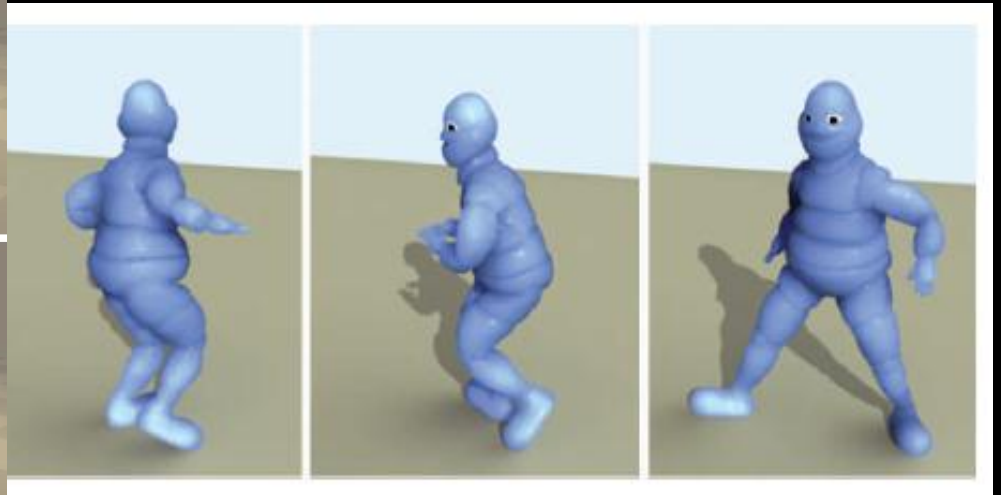
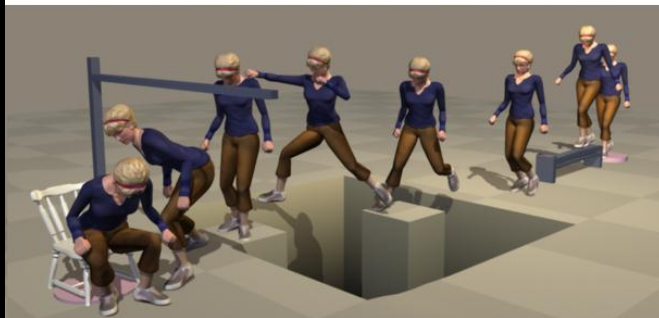
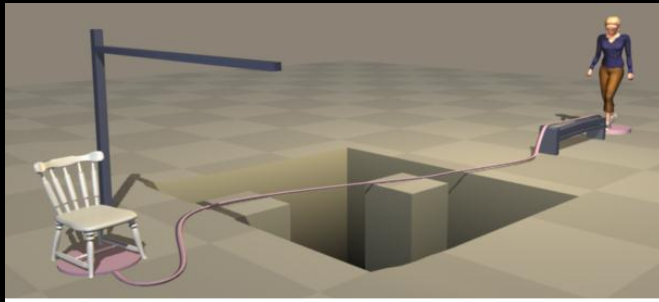
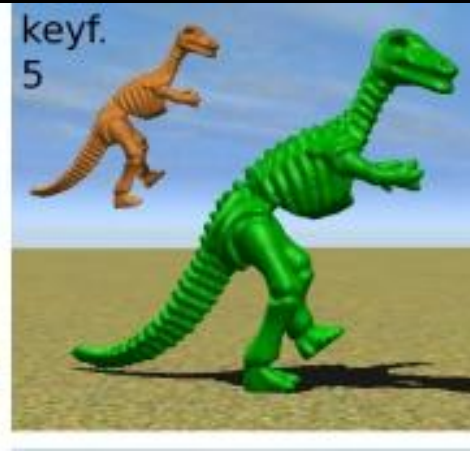
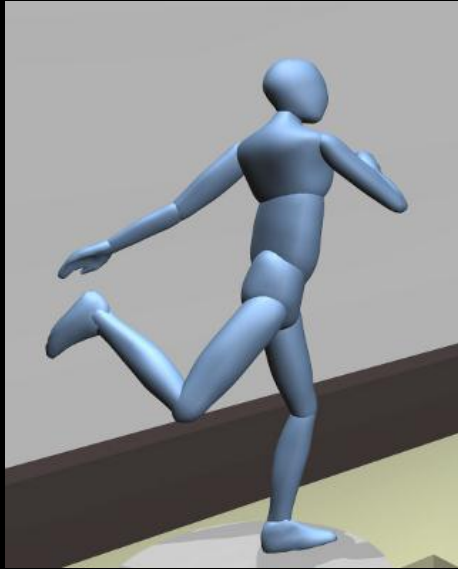


# Character Animation: Trends and Techniques from Recent Research



First, a look at traditional animation...

# Principles of Traditional Animation

## [Lasseter, SIGGRAPH 1987]

- Stylistic conventions followed by Disney's animators and others
- From experience built up over many years
  - Squash and stretch -- use distortions to convey flexibility
  - Timing -- speed conveys mass, personality
  - Anticipation -- prepare the audience for an action
  - Followthrough and overlapping action -- continuity with next action
  - Slow in and out -- speed of transitions conveys subtleties
  - Arcs -- motion is usually curved
  - Exaggeration -- emphasize emotional content
  - Secondary Action -- motion occurring as a consequence
  - Appeal -- audience must enjoy watching it

# Principles of Traditional Animation

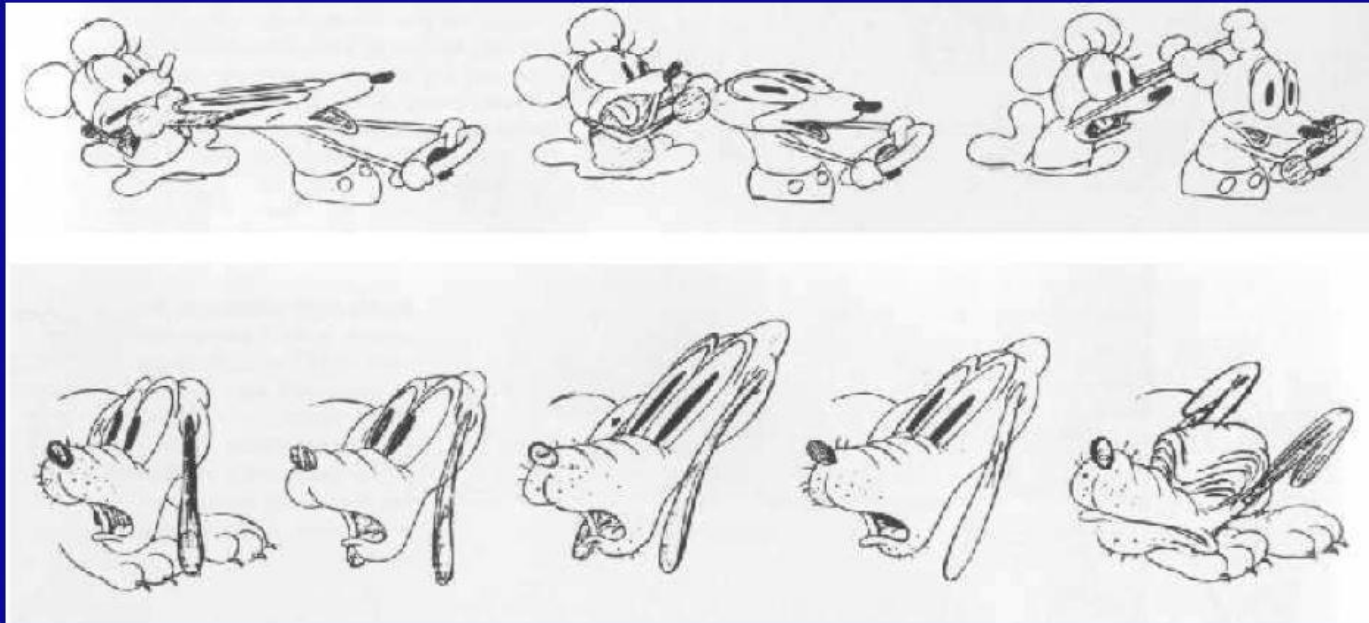


*The famous half-filled flour sack, guide to maintaining volume in any animatable shape, and proof that attitudes can be achieved with the simplest of shapes.*



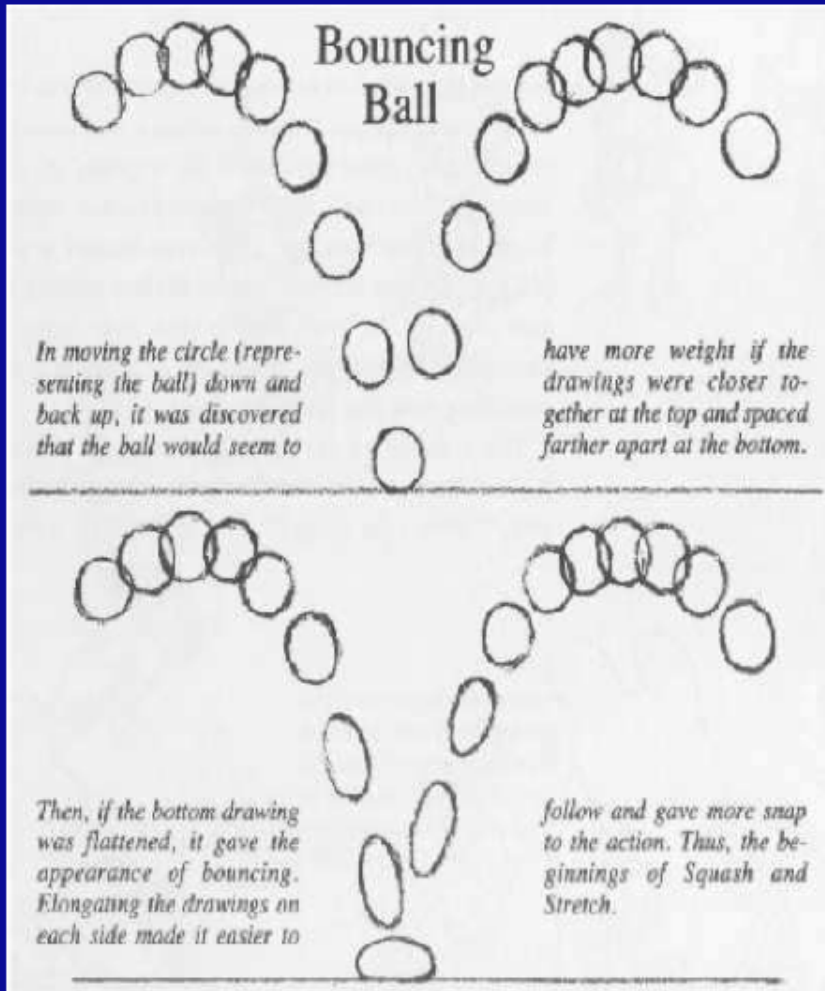
# Squash and Stretch

Use distortions to convey flexibility



# Squash and Stretch

Use distortions to convey flexibility



Defines the rigidity of the material

Gives the sense that the object is made out of a soft, pliable material.

Elongating the drawings before and after the bounce increases the sense of speed, makes it easier to follow and gives more snap to the action.

# Timing & Motion

## Timing can also indicate an emotional state

Consider a scenario with a head looking first over the right shoulder and then over the left shoulder

No in-betweens - the character has been hit by a strong force and its head almost snapped off

One in-betweens - the character has been hit by something substantial, .e.g., frying pan

Two in-betweens - the character has a nervous twitch

Three in-betweens - the character is dodging a flying object

Four in-betweens - the character is giving a crisp order

Six in-betweens - the character sees something inviting

Nine in-betweens - the character is thinking about something

Ten in-betweens - the character is stretching a sore muscle

# Anticipation

Prepare the audience for an action



Don't surprise the audience  
Direct their attention to what's important



# Follow Through and Overlapping Action

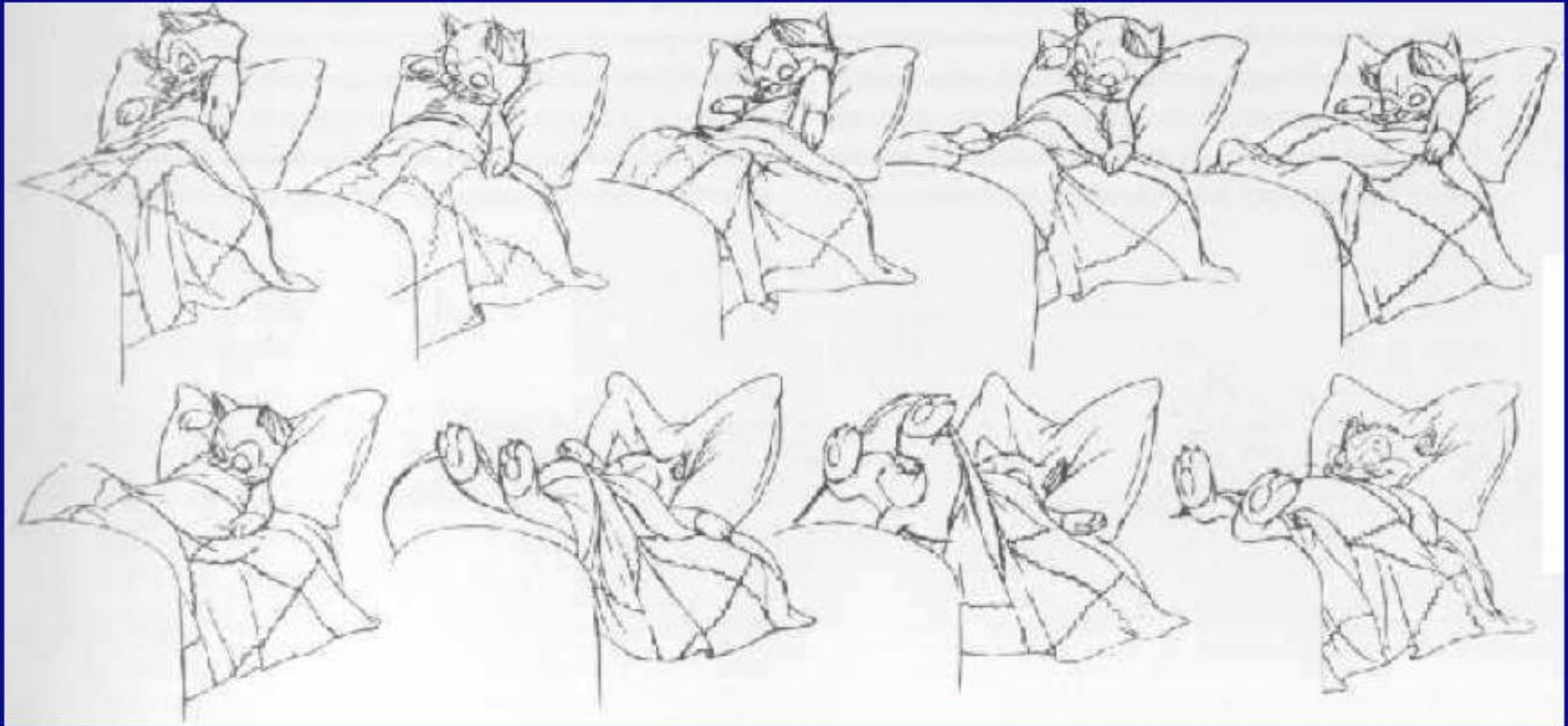
The termination of an action and establishing its relationship to the next action



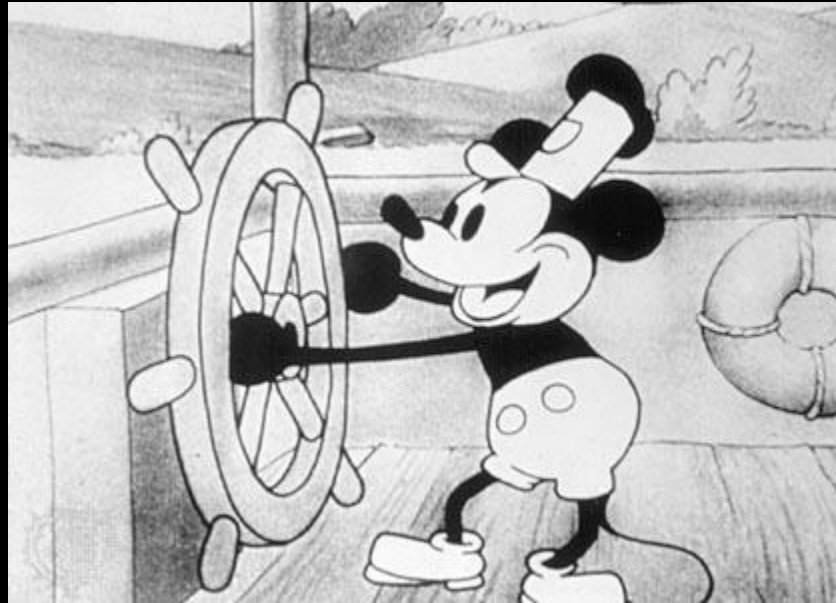
Audience likes to see resolution of action  
Discontinuities are unsettling

## Secondary Action

Motion occurring as a consequence



We're going to look at the technology, but in the end, it's all about the story and the acting....



# Outline

## Motion Capture

Assessing results from the motion capture revolution

## Physically-based Simulation

Making animations more realistic and of-the-moment?

## Artist Tools for Character Animation

Giving total control back to the artists

## Artist Tools for 2D Image Creation and Animation

# The Motion Capture Revolution

Motion capture labs became accessible about 10 years ago....



*motion capture lab at CMU*

Advances have led to performance capture as seen in Avatar



*motion capture in the movie Avatar*

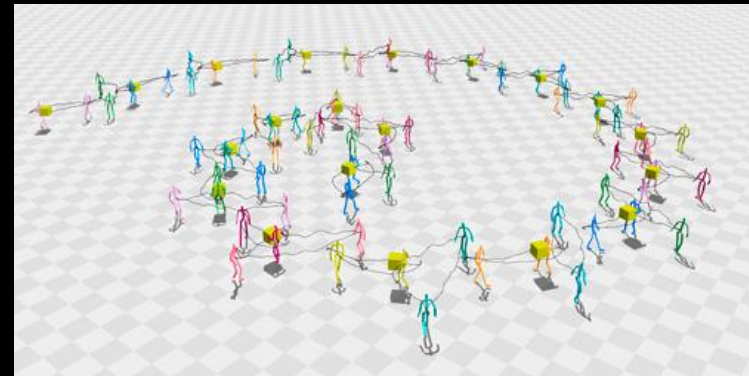
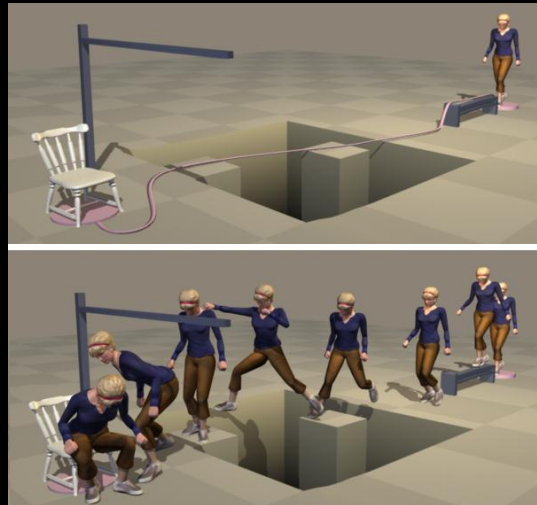
<http://www.youtube.com/watch?v=L6JXUoWeZ7Q>

# The Motion Capture Revolution

What if we can't afford to capture an entire script?

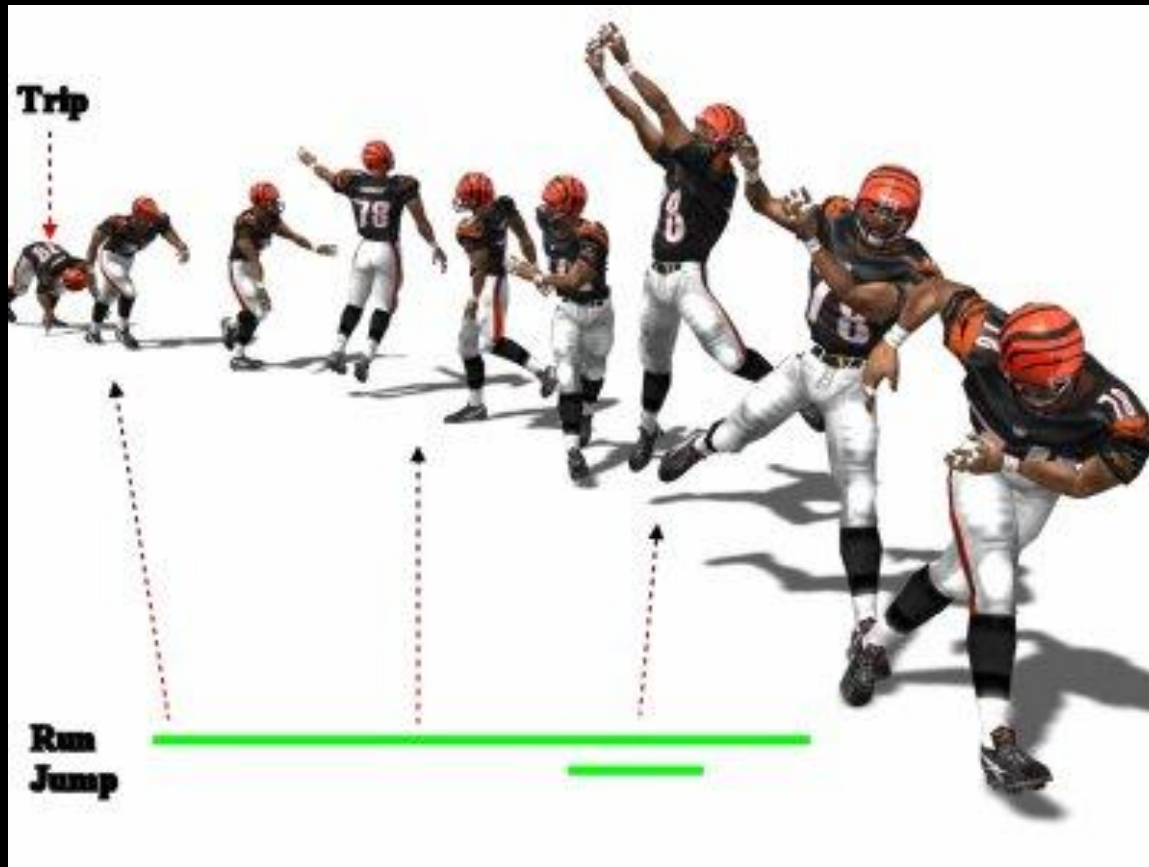
What if we want new real-time performances in response to user actions?

*Vision: create a vast database of human activities, interactions, emotions for general use.*



# Motion Capture Databases

Okan Arikan's research stands the test of time for real-time scripting

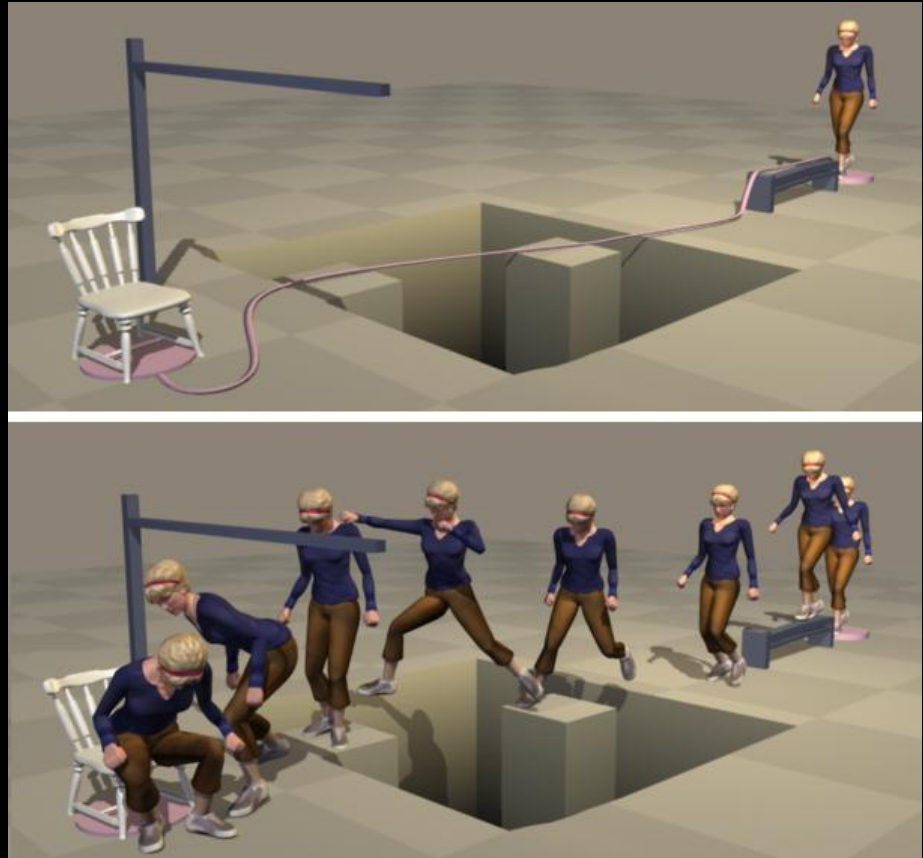


Okan Arikan, David A. Forsyth, James O'Brien. Motion Synthesis from Annotations. ACM Transactions on Graphics (ACM **SIGGRAPH** 2003), Vol: 33, No: 3, pp 402--408, 2003.

# Motion Capture Databases

Alla Safonova's research creates beautiful scripted results in a longer offline process

*key: allow interpolation between existing motions*



Alla Safonova and Jessica K. Hodgins

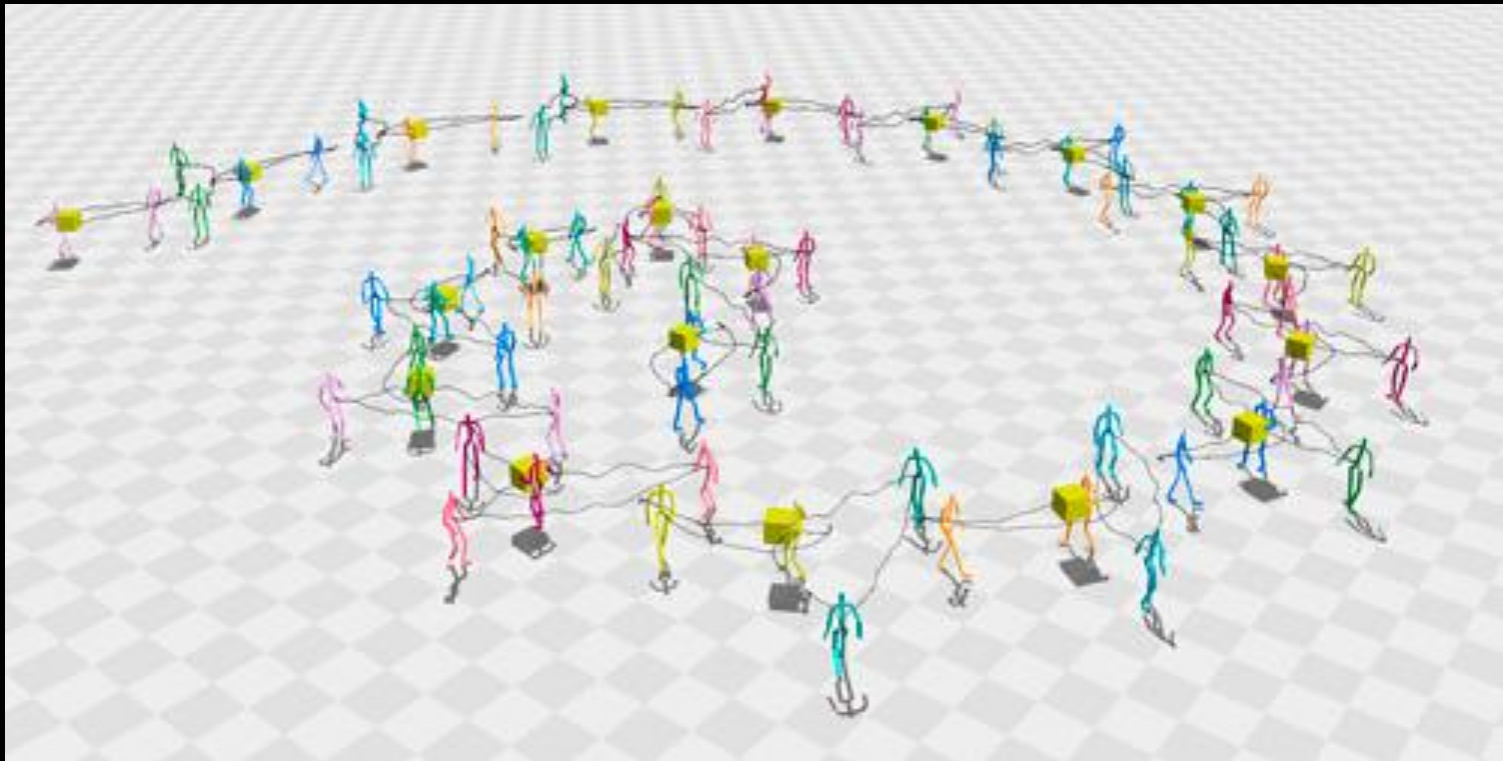
Construction and optimal search of interpolated motion graphs

ACM Transactions on Graphics Journal, SIGGRAPH 2007 Proceedings, August 2007



# Motion Capture Databases

Jehee Lee has created elegant real-time editing tools for captured motion data



Manmyung Kim, Kyung Lyul Hyun, Jongmin Kim, Jehee Lee,  
Synchronized Multi-Character Motion Editing,  
ACM Transactions on Graphics (SIGGRAPH 2009), Vol. 28, No. 3, August 2009

# Motion Capture Databases – Challenges

*What about hands?*



# Motion Capture Databases – Hands

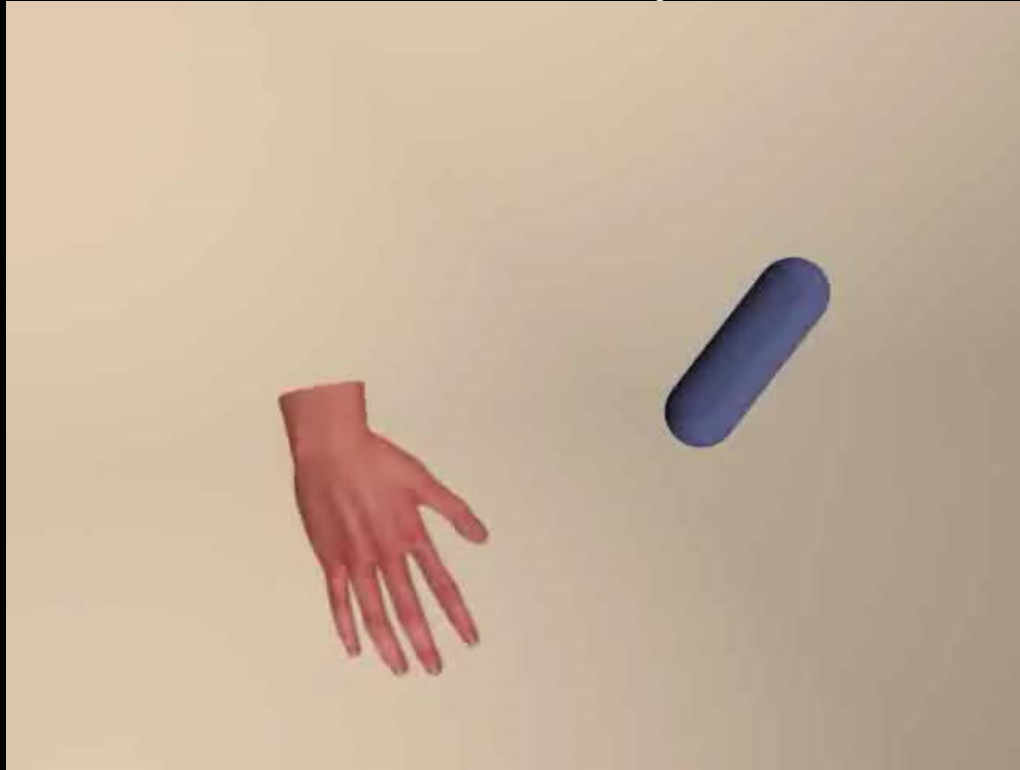
We can create physical simulations from motion capture data to help us achieve realistic hand-object contact



N. S. Pollard and Victor B. Zordan, 2005. Physically Based Grasping Control from Example, ACM SIGGRAPH / Eurographics Symposium on Computer Animation, Los Angeles, CA, pp 311-318, 2005.

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# Motion Capture Databases – Hands

## *Lessons learned:*

Separating passive and active control makes it easier to set control parameters



stiffness  
and  
damping

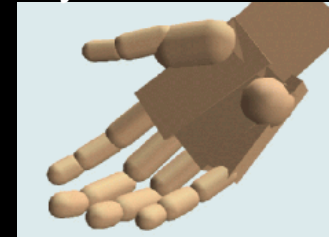
Joint limits are important, and easy to extract from motion data



no joint  
limits

Palm geometry is important for grasping

Physical Model



local  
minima

N. S. Pollard and Victor B. Zordan, 2005. Physically Based Grasping Control from Example, ACM SIGGRAPH / Eurographics Symposium on Computer Animation, Los Angeles, CA, pp 311-318, 2005.

# Motion Capture Databases – Hands

Karen Liu creates animations from captured or preset grasping poses and the assumption that people try to maintain *constant hand joint torques* during manipulation



C. Karen Liu, Dextrous Manipulation from a Grasping Pose, in ACM Transactions on Graphics (SIGGRAPH) 2009

# Motion Capture Databases – Challenges

*What about faces?*



# Motion Capture Databases – Challenges

*What about skin deformation?*



Sang Il Park and Jessica K. Hodgins. Capturing and animating skin deformation in human motion. ACM Transactions on Graphics (SIGGRAPH 2006), 25(3), August 2006.



# Motion Capture Databases – Skin Deformation

Jessica Hodgins promotes full capturing of skin deformation during dynamic activities

## Experimental Results

Sang Il Park and Jessica K. Hodgins. Capturing and animating skin deformation in human motion. ACM Transactions on Graphics (SIGGRAPH 2006), 25(3), August 2006.

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# Physically-Based Simulation

Victor Zordan demonstrates use of physical simulation to capture that moment of impact

## Dynamic Response for Motion Capture Animation

Dynamic Response for Motion Capture Animation  
Zordan, V. B., Majkowska, A., Chiu, B., Fast, M.  
ACM SIGGRAPH 2005

# Physically-Based Simulation

Victor Zordan demonstrates use of physical simulation to capture that moment of impact

Interactive  
Dynamic Response  
For Games

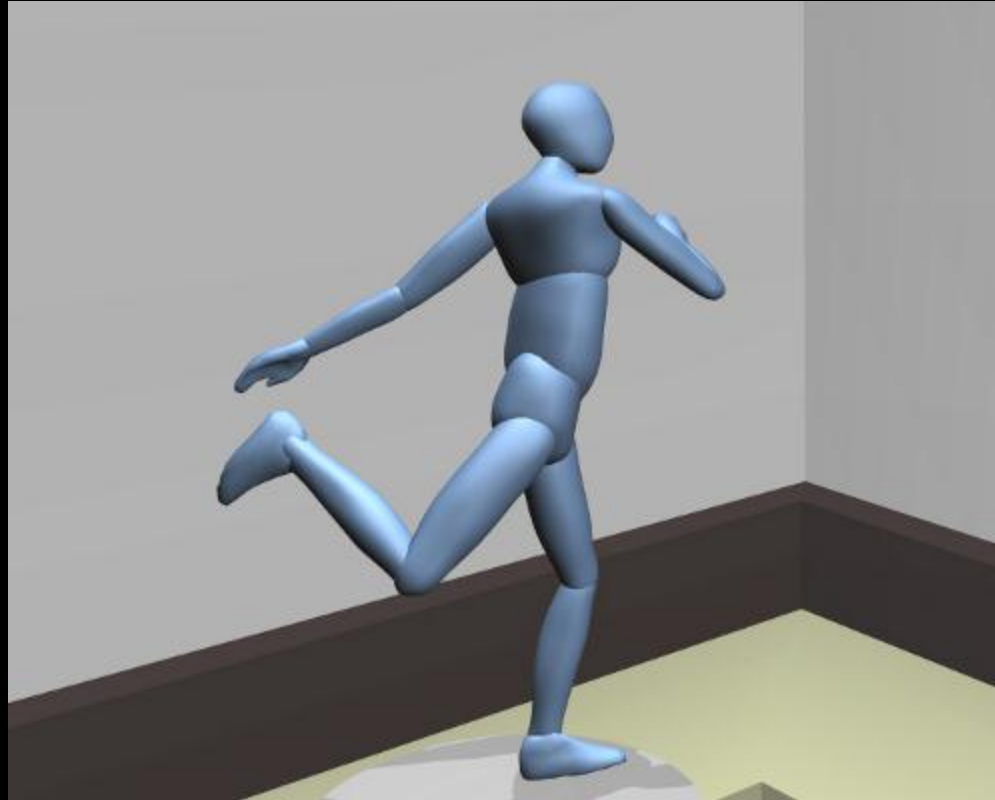
Interactive Dynamic Response for Games

Zordan, V.B., Macchietto, A., Medina, J., Soriano, M., Wu, C.C.

ACM SIGGRAPH Sandbox Symposium 2007

# Physically-Based Simulation

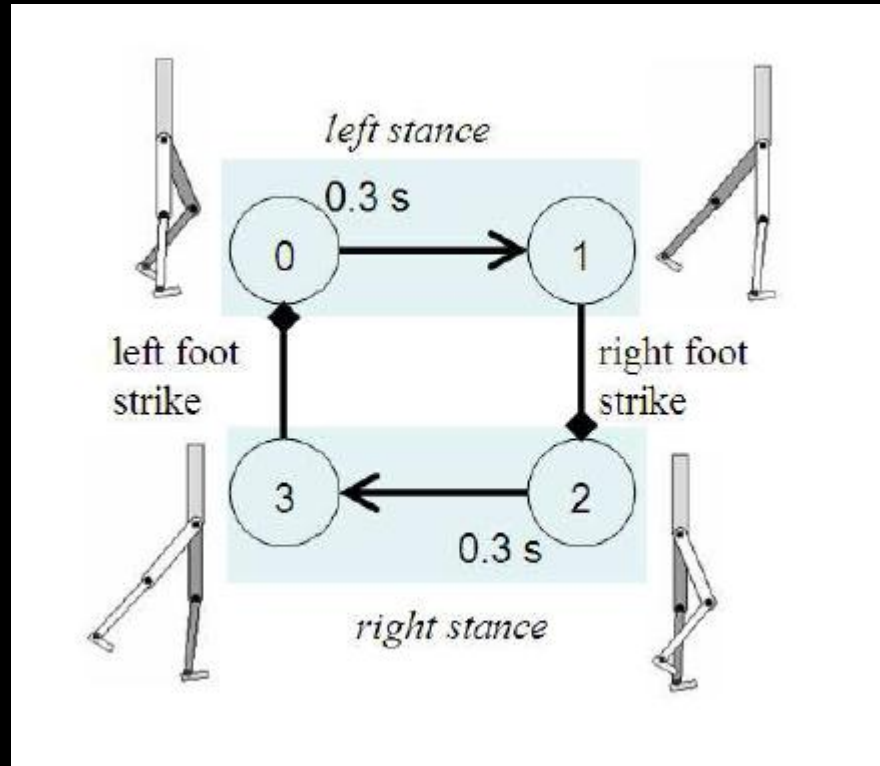
Physically-based simulation is also great for standing balance



Momentum Control for Balance  
Macchietto, A., Zordan, V.B., Shelton C.,  
Transactions on Graphics/ACM SIGGRAPH 2009.

# Physically-Based Simulation

Pose-control graphs combined with dynamic simulation are making a powerful comeback recently



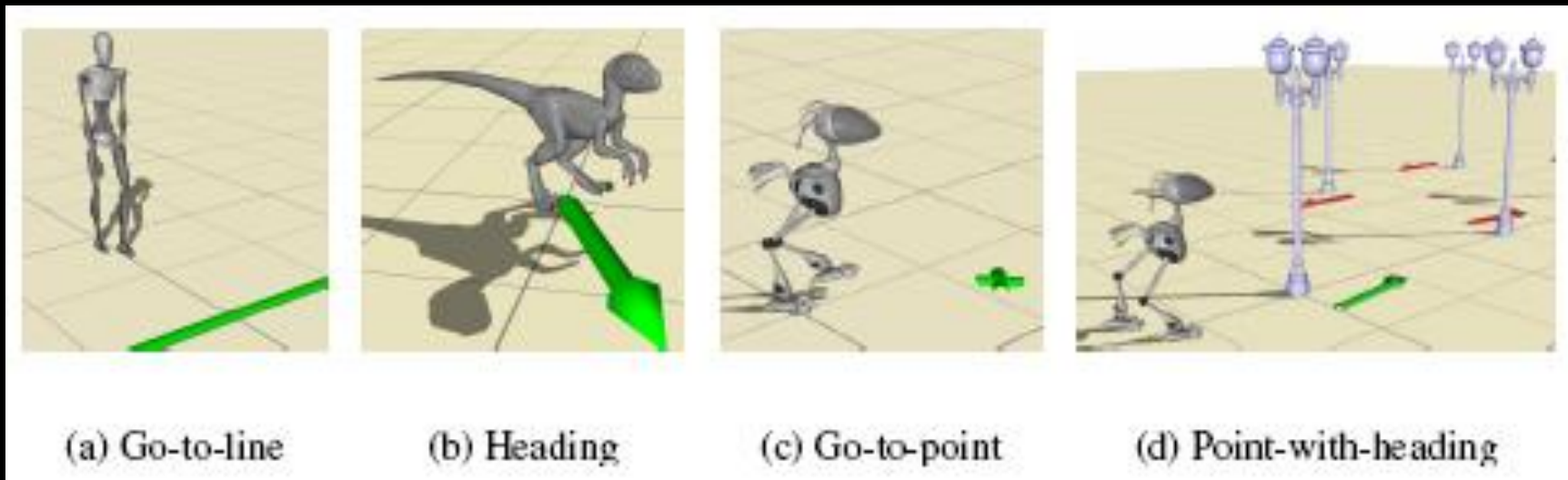
SIMBICON: Simple Biped Locomotion Control

KangKang Yin, Kevin Loken, and Michiel van de Panne

ACM Transactions on Graphics (Proc. ACM SIGGRAPH 2007)

# Physically-Based Simulation: Pose Based Controllers

Van de Panne's group combines their own pose-based controllers with task-level information for characters that convey some level of intent

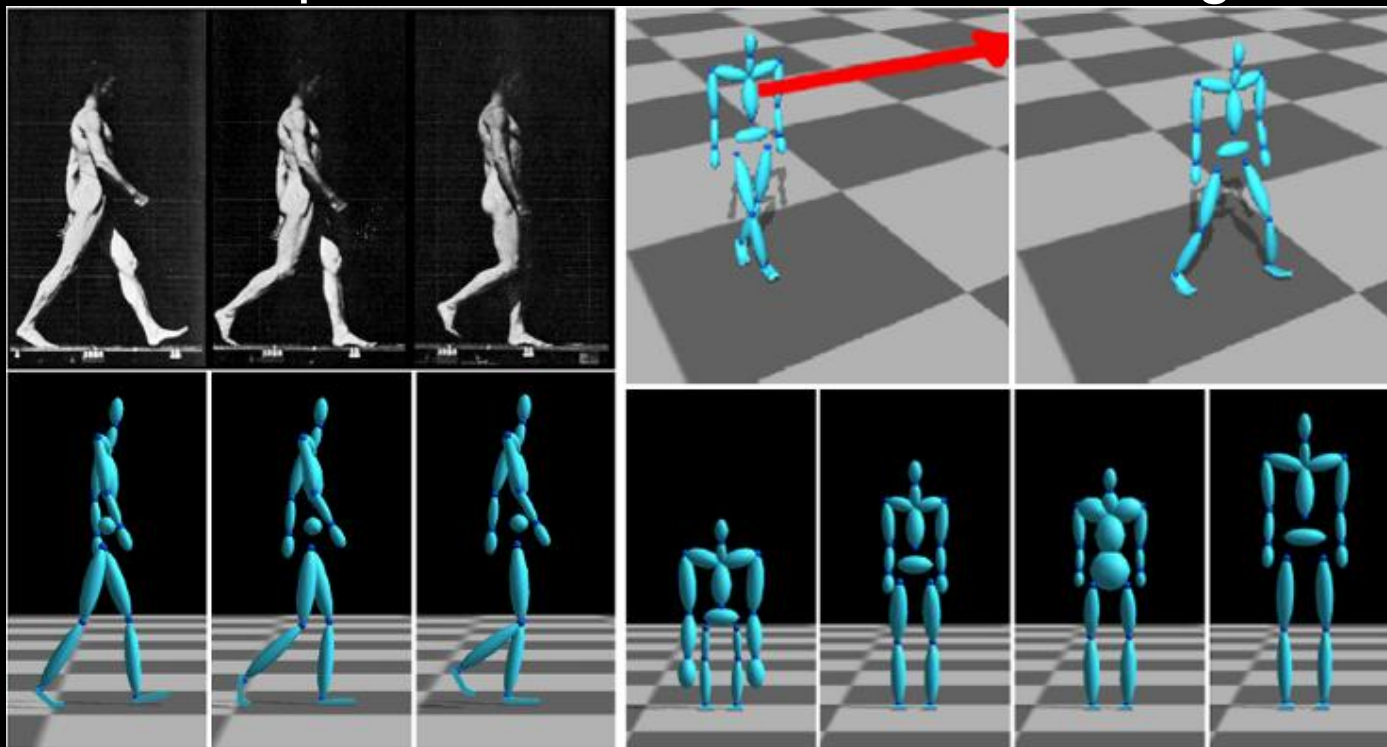


Robust Task-based Control Policies for Physics-based Characters  
Stelian Coros, Philippe Beaudoin, Michiel van de Panne  
ACM Transactions on Graphics (Proc. ACM SIGGRAPH ASIA 2009)



# Physically-Based Simulation: Pose Based Controllers

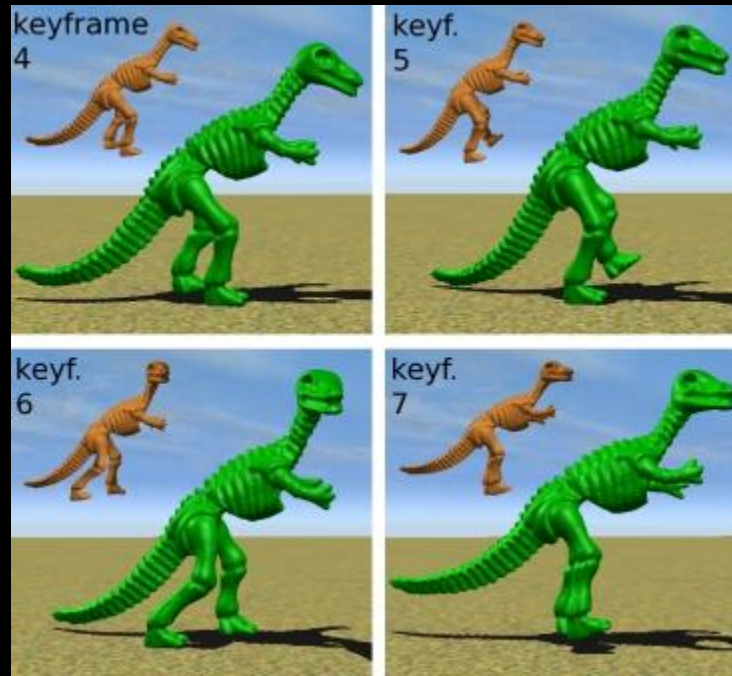
Herzmann's group augments pose-based controllers with optimization to produce more humanlike walking



Wang, J. M., Fleet, D. J., Hertzmann, A. Optimizing Walking Controllers. ACM Transactions on Graphics 28, 5 (Proceedings of SIGGRAPH Asia 2009), Article 168, December 2009

# Physically-Based Simulation: Pose Based Controllers

Great progress has been made with deformable shapes as well, as shown by the work of Barbic and J. Popovic



Jernej Barbic, Marco da Silva, Jovan Popović:  
Deformable Object Animation Using Reduced Optimal Control, ACM Transactions on  
Graphics 28(3) (SIGGRAPH 2009), New Orleans, Aug 2009

# Artist Tools for Animation

Artist development tools for Spore indicate an exciting trend



Chris Hecker, Bernd Raabe, Ryan W. Enslow, John DeWeese, Jordan Maynard, Kees van Prooijen, Real-time Motion Retargeting to Highly Varied User-Created Morphologies, SIGGRAPH 2008

# Artist Tools for Animation

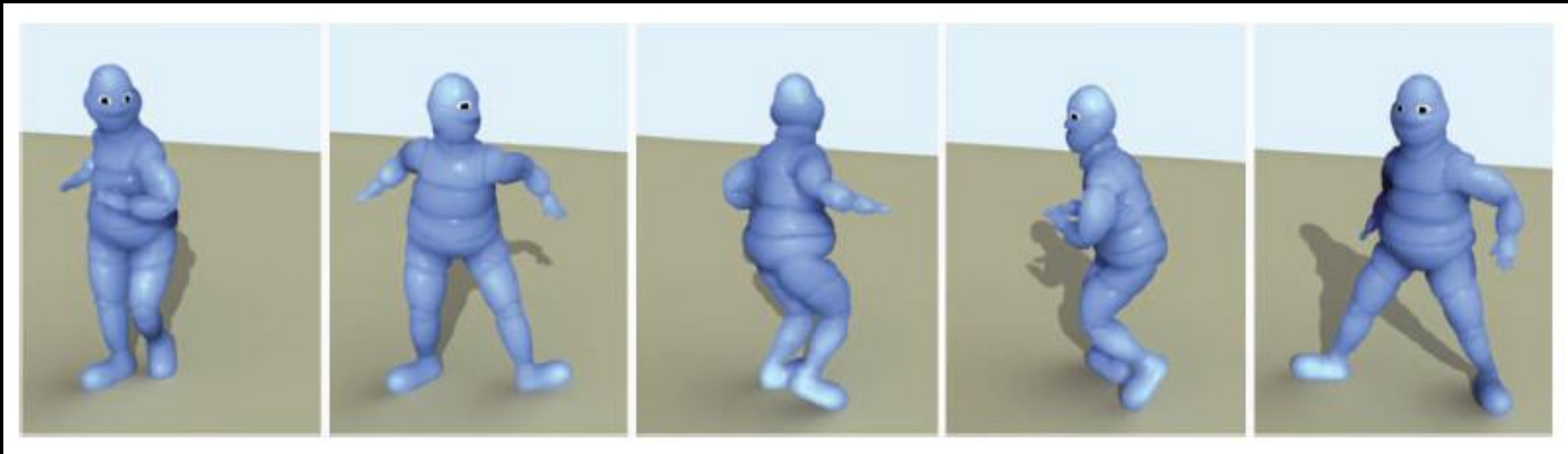
We are working to create direct control of a running simulation



Junggon Kim and Nancy S. Pollard, "Direct Control of Simulated Non-human Characters," IEEE Computer Graphics and Applications (in press).

# Artist Tools for Animation

Real-time control requires new techniques for fast simulation of deformable bodies



Junggon Kim and Nancy S. Pollard. "Fast Simulation of Skeleton-driven Deformable Body Characters", ACM Transactions on Graphics (in press)

# Artist Tools for 2D Editing and Animation

Painting in the gradient domain creates new opportunities for the artist



J. McCann and N. S. Pollard, 2008. Real-Time Gradient-Domain Painting, ACM Transactions on Graphics 27(3), SIGGRAPH 2008 Proceedings

# Artist Tools for 2D Editing and Animation

Local tools for layering elements can be used for creation of images and animations



J. McCann and N. S. Pollard, 2009. Local Layering, ACM Transactions on Graphics 28(3), SIGGRAPH 2009 Proceedings, August 2009

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