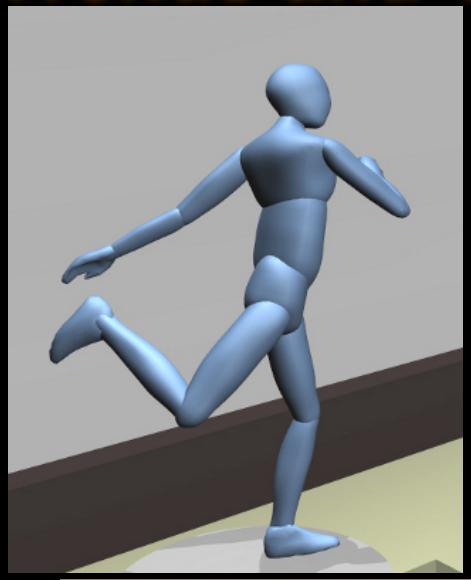
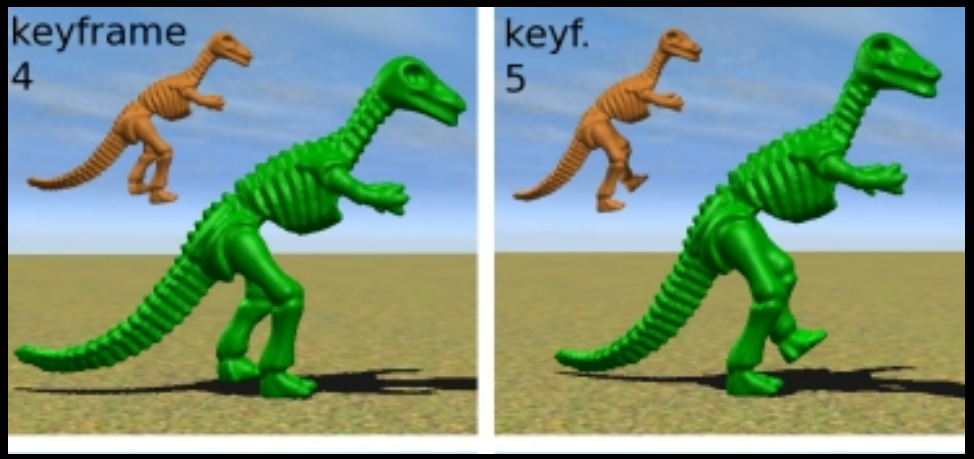
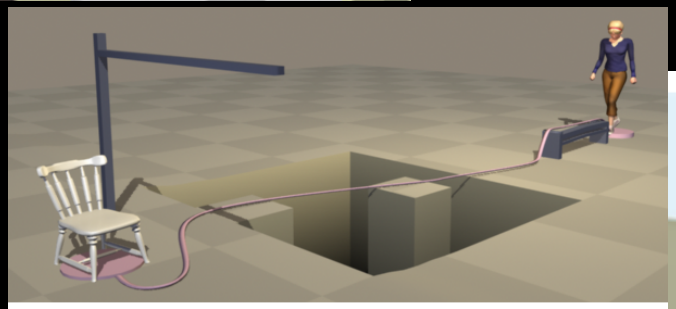
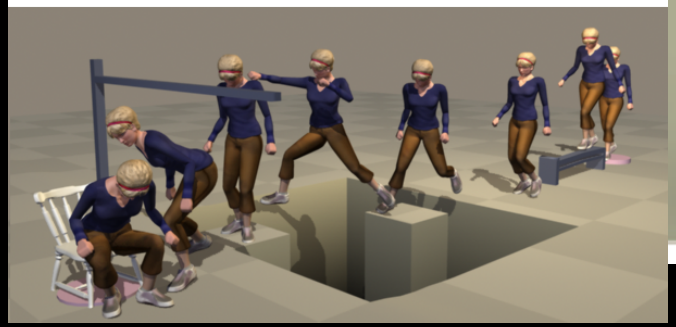
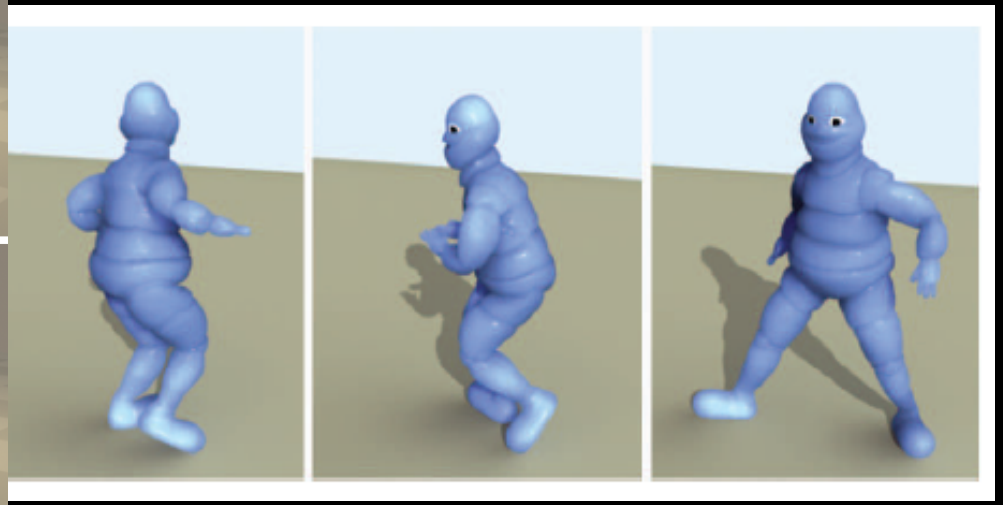
Character Animation:
Trends and Techniques from Recent Research











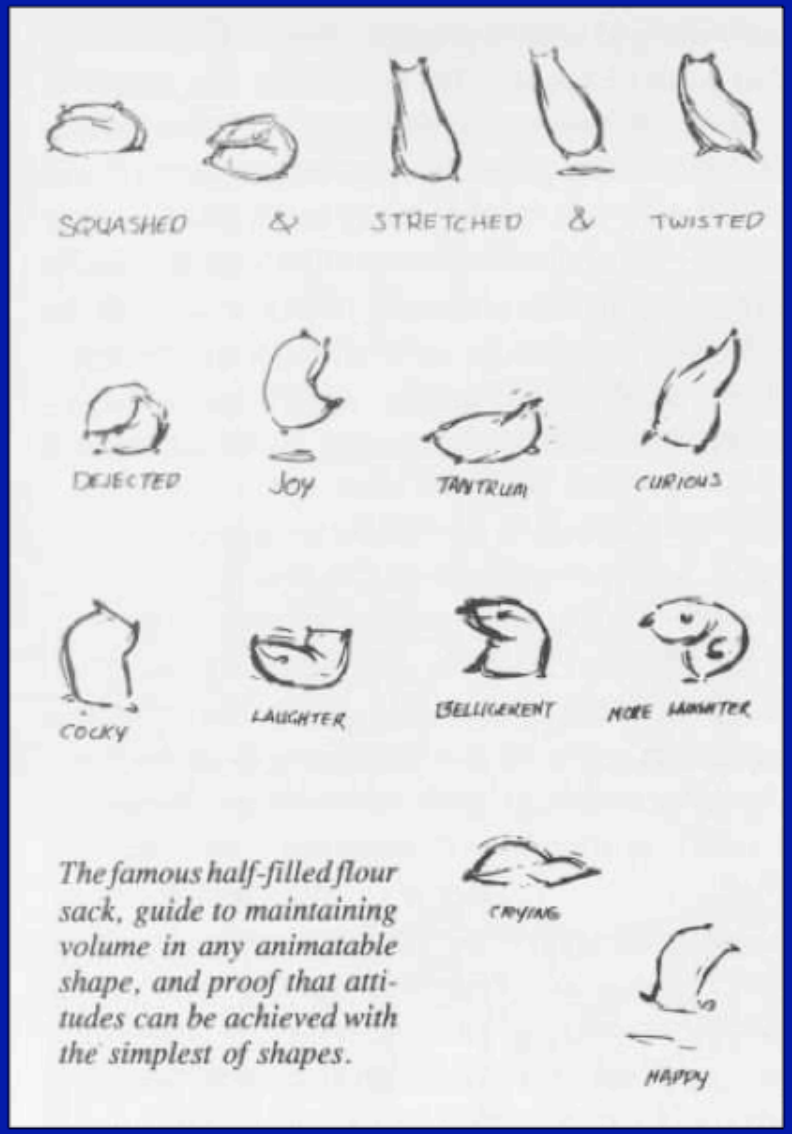
First, a look at traditional animation...

Principles of Traditional Animation
[Lasseter, SIGGRAPH 1987]

- Stylistic conventions followed by Disney's animators and others

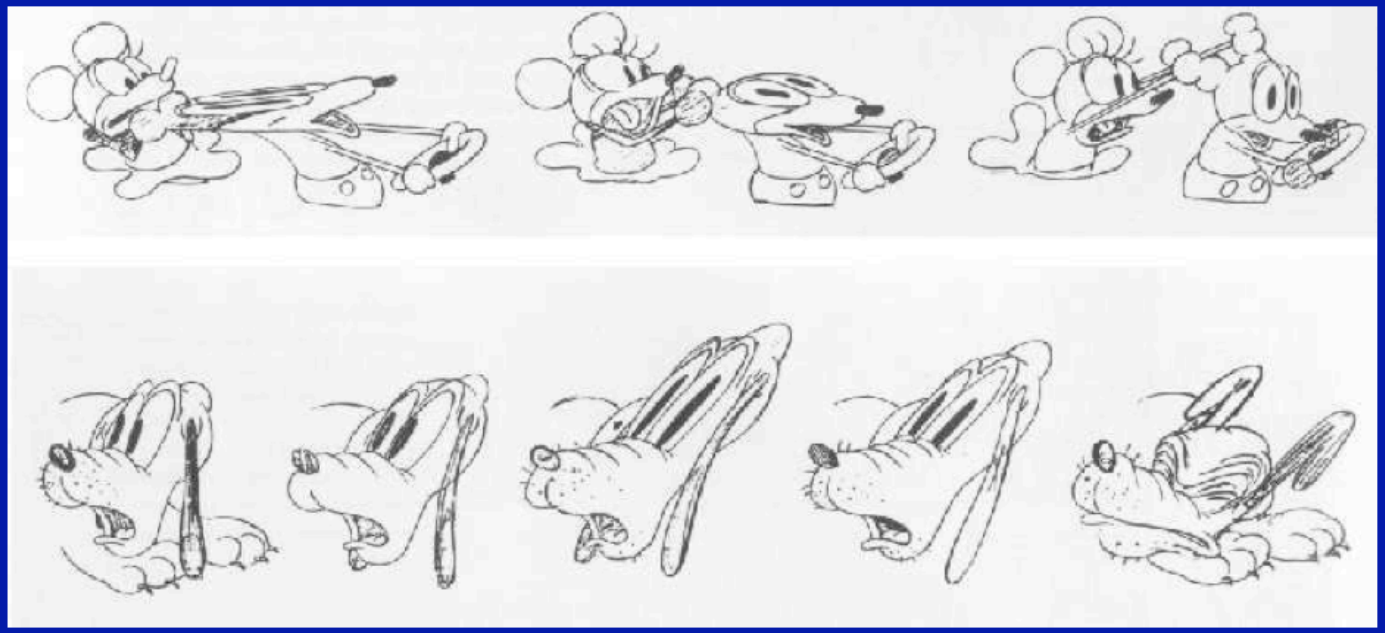
- From experience built up over many years
  - Squash and stretch -- use distortions to convey flexibility
  - Timing -- speed conveys mass, personality
  - Anticipation -- prepare the audience for an action
  - Followthrough and overlapping action -- continuity with next action
  - Slow in and out -- 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



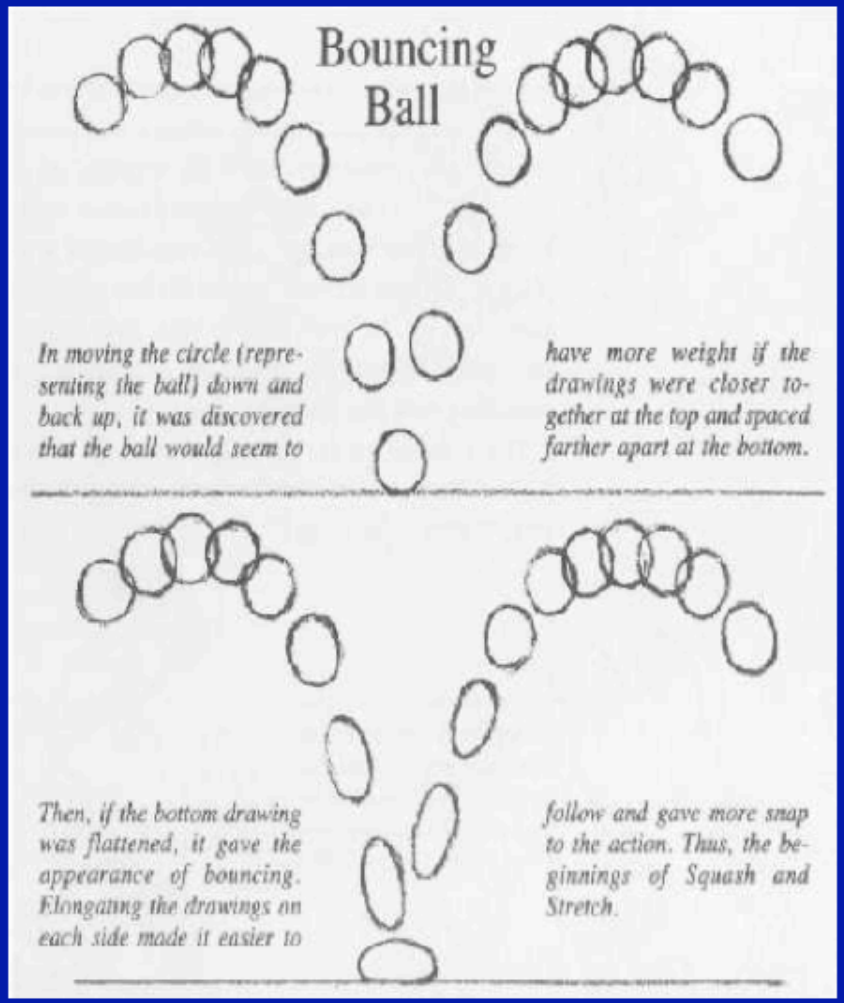
Squash and Stretch

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 snappedd 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

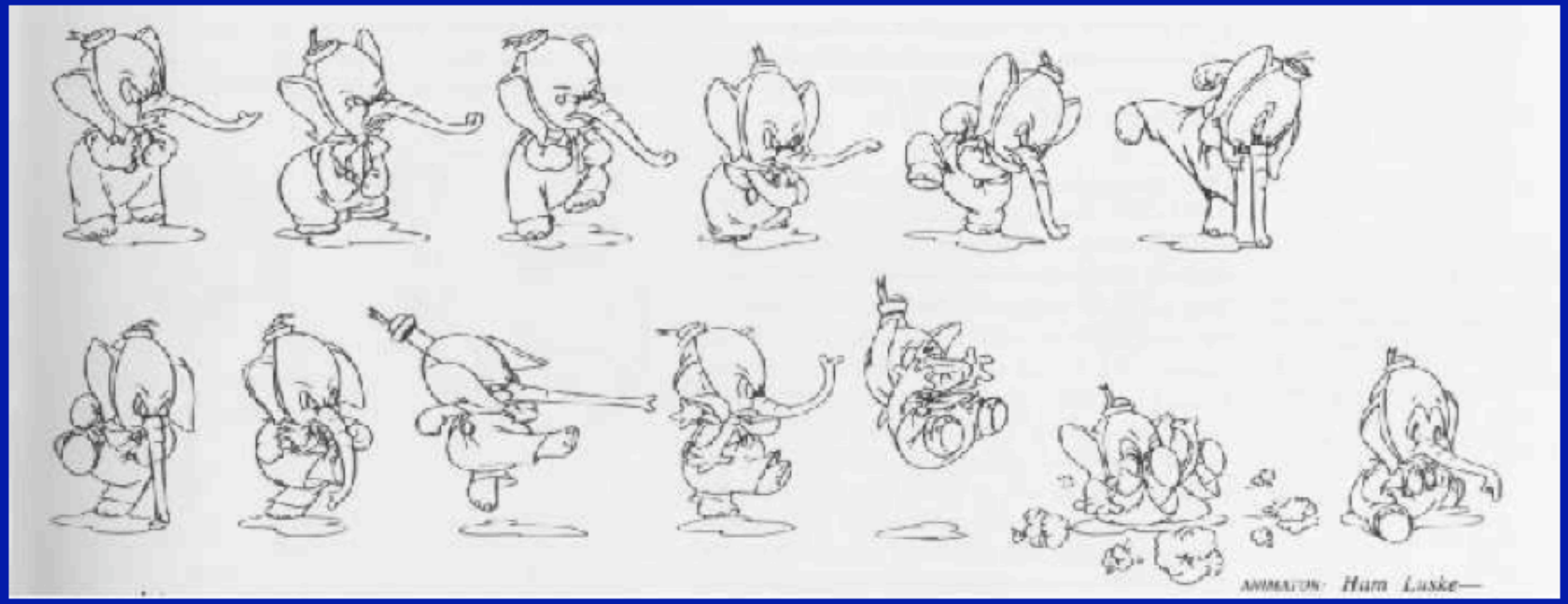
Anticipation

Prepare the audience for an action

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

Follow Through and Overlapping Action

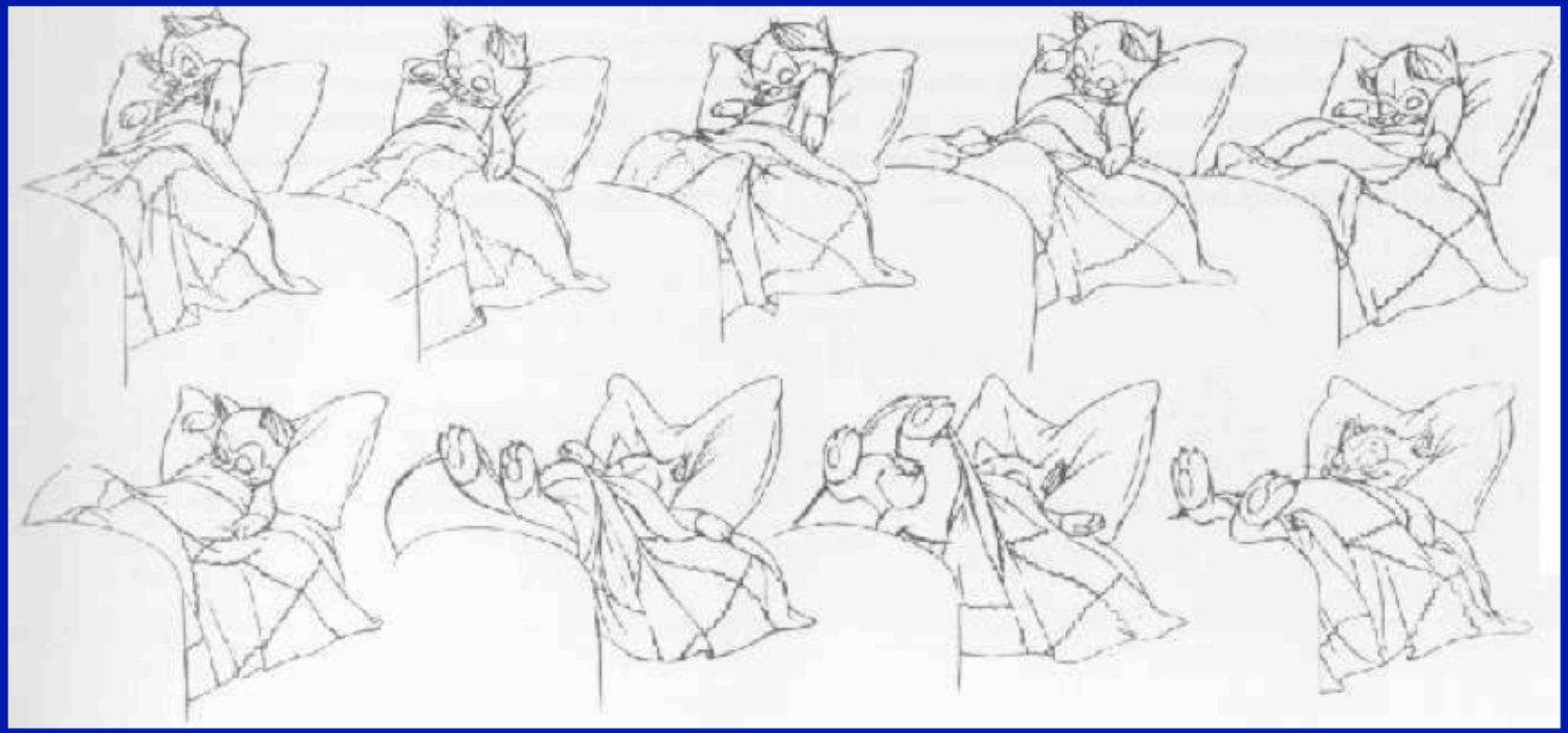
The termination of an action and establishing its relationship to the next action



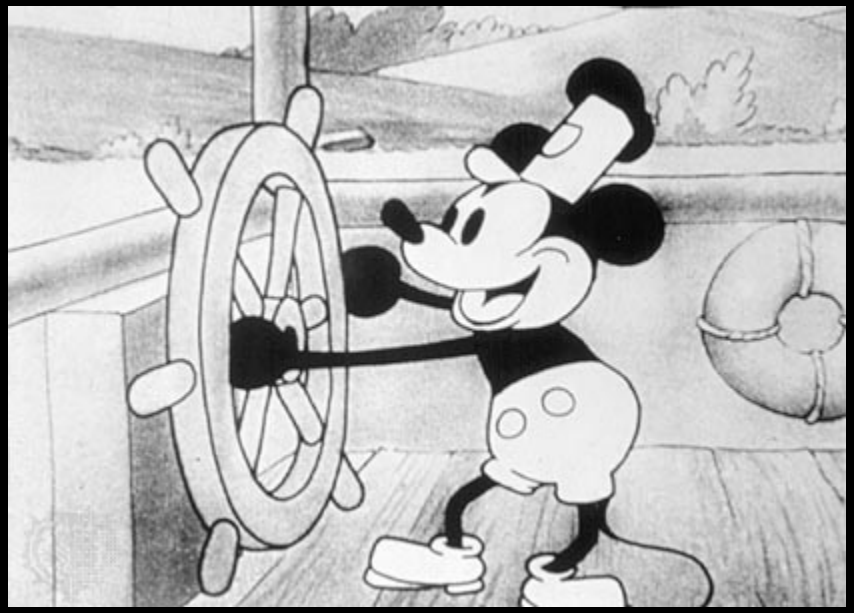
Audience likes to see resolution of action
Discontinuities are unsettling

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 15 years ago....

motion capture lab at CMU

Advances have led to performance capture as seen in Avatar

motion capture in the movie Avatar

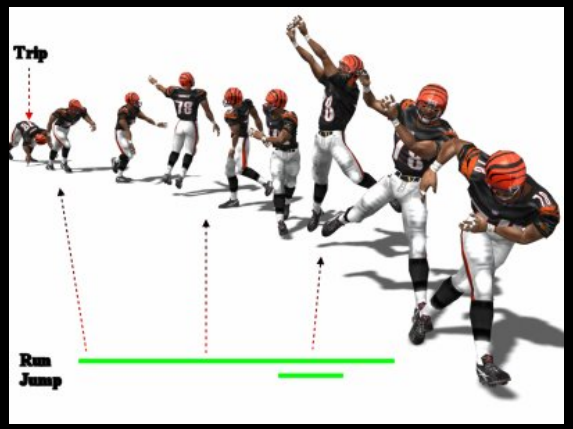
http://www.youtube.com/watch?v=L6JXUoWeZ7Q

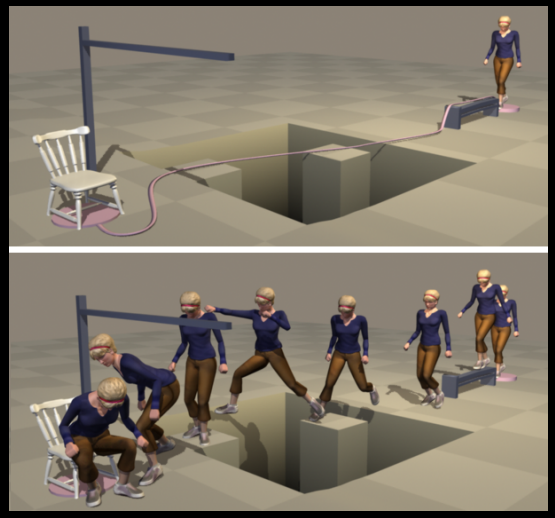
The Motion Capture Revolution

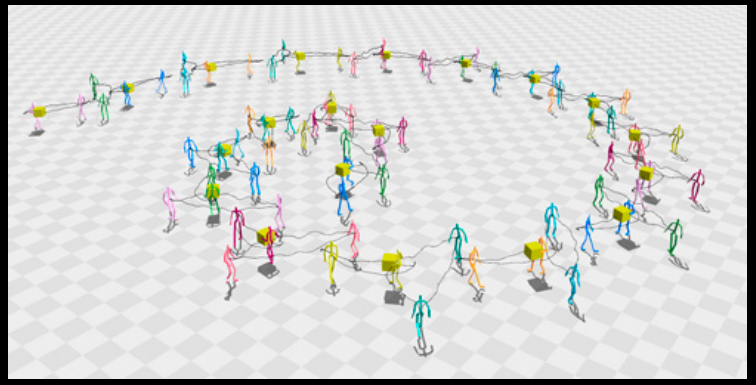
What if we can't afford to capture an entire script?

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.

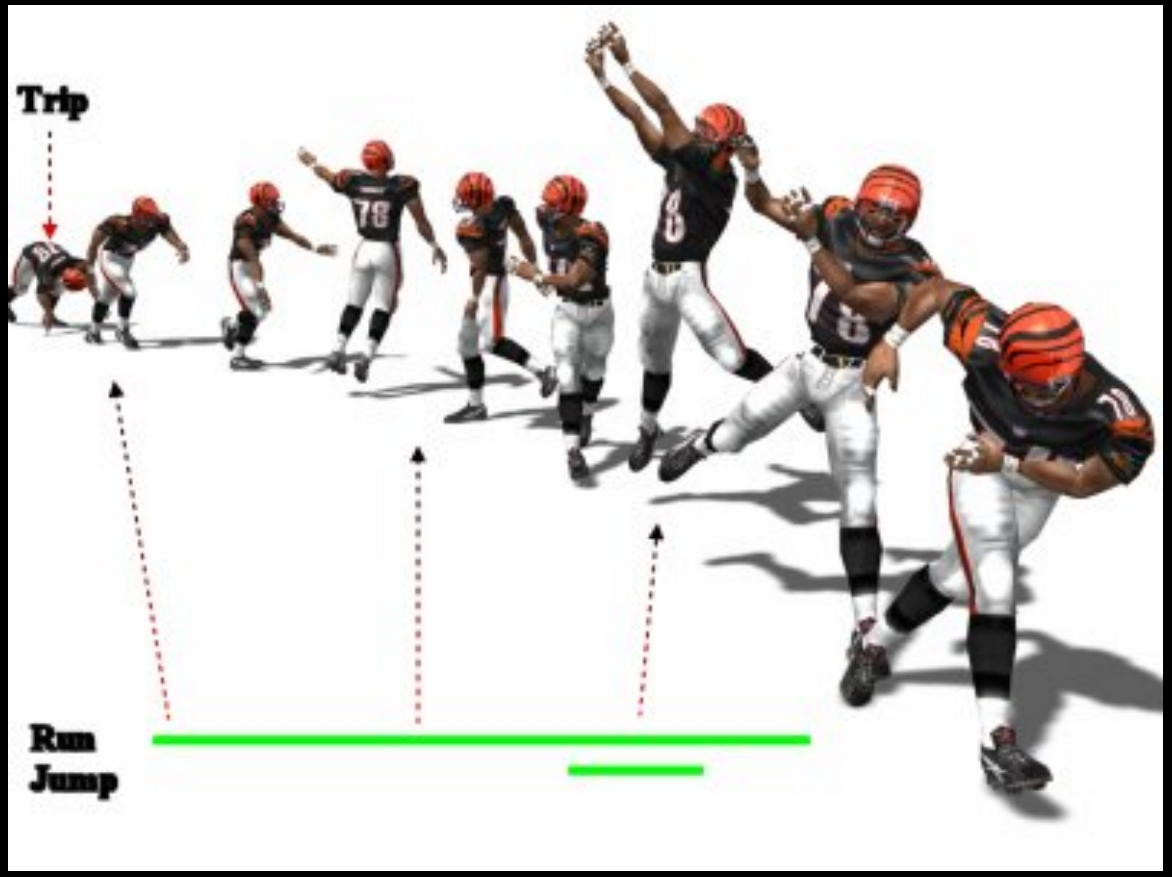






Motion Capture Databases

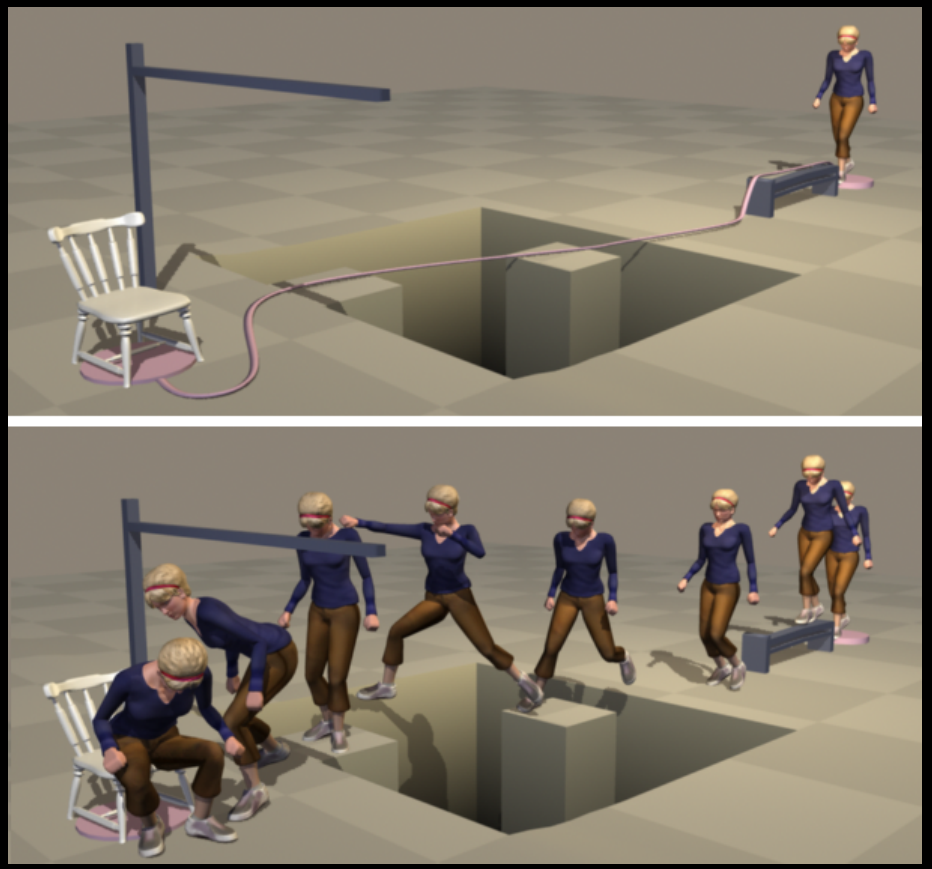
Okan Arikan's research stands the test of time for real-time scripting



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

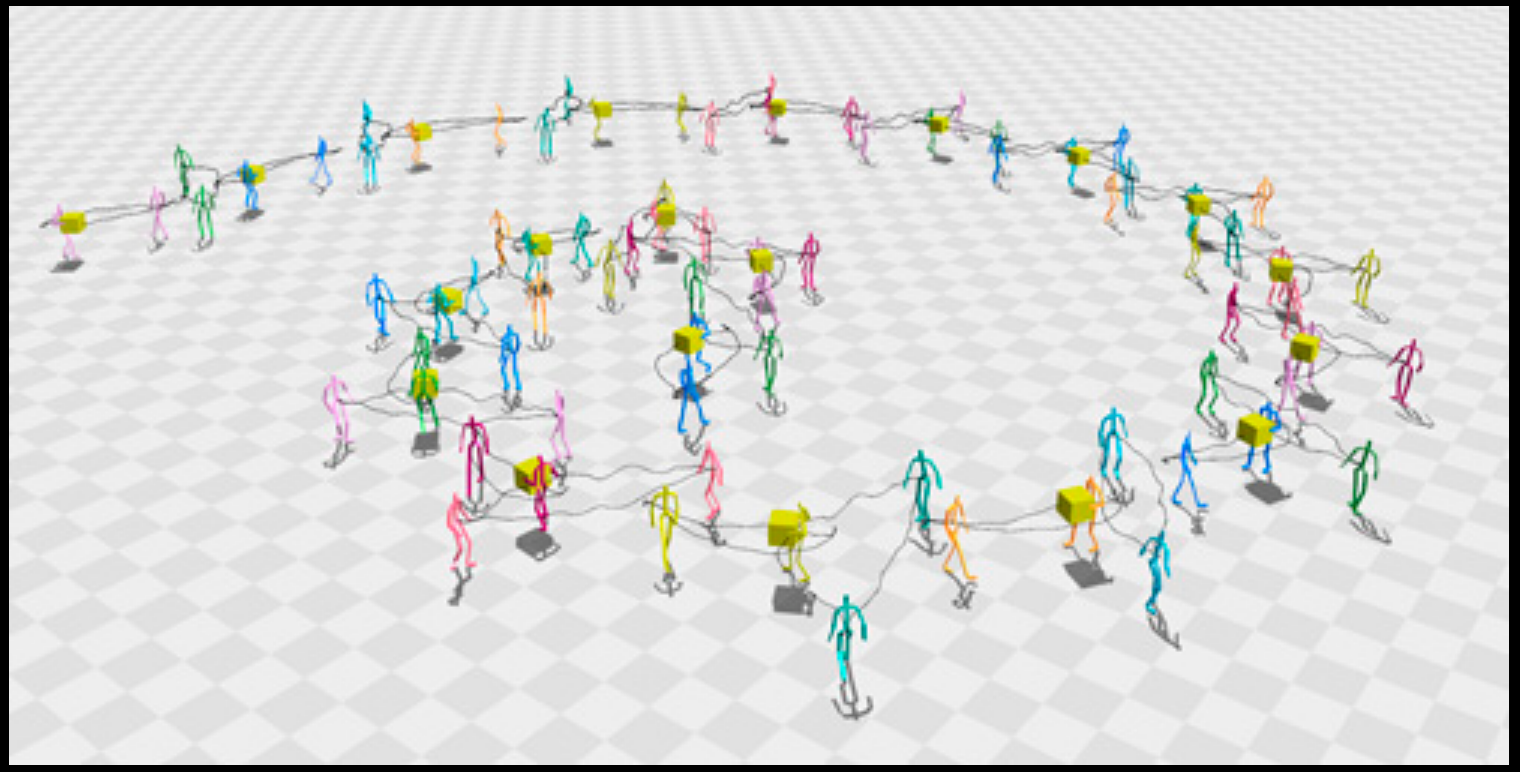


key: allow interpolation between existing motions

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 Graphcis (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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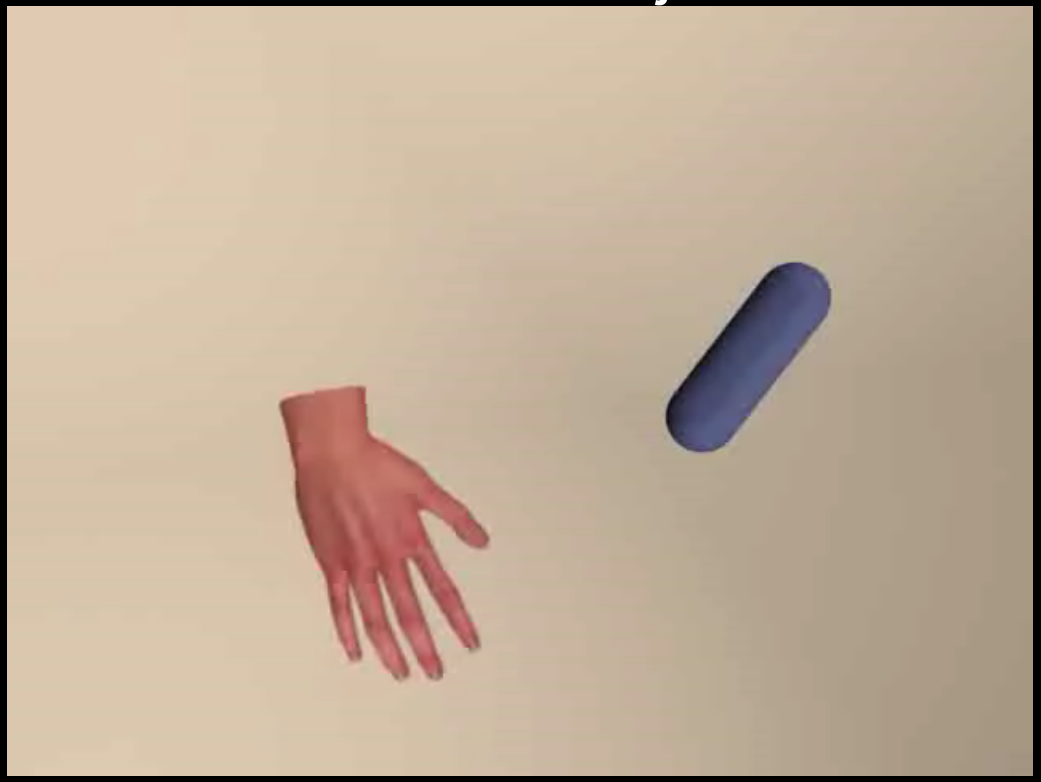


N. S. Pollard and Victor B. Zordan, 2005. Physically Based Grasping Control from Example, ACM SIGGRAPH / Eurographics Symposium on Computer Animation, Los Angeles, CA, pp 311-318, 2005.

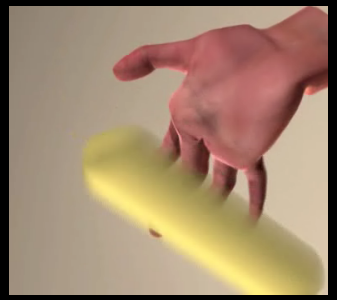
Motion Capture Databases – Hands

Lessons learned:

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

stiffness and damping

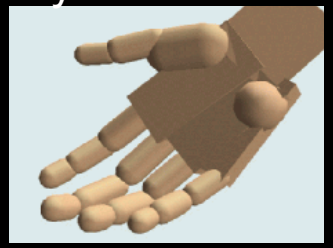
Joint limits are important, and easy to extract from motion data



no joint limits

Physical Model

Palm geometry is important for grasping



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?

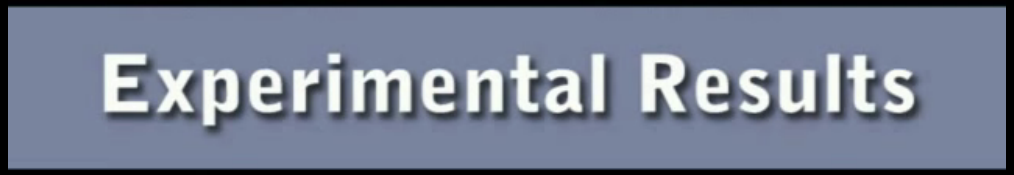
Motion Capture Databases – Challenges

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



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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
Zordan, V. B., Majkowska, A., Chiu, B., Fast, M.
ACM SIGGRAPH 2005

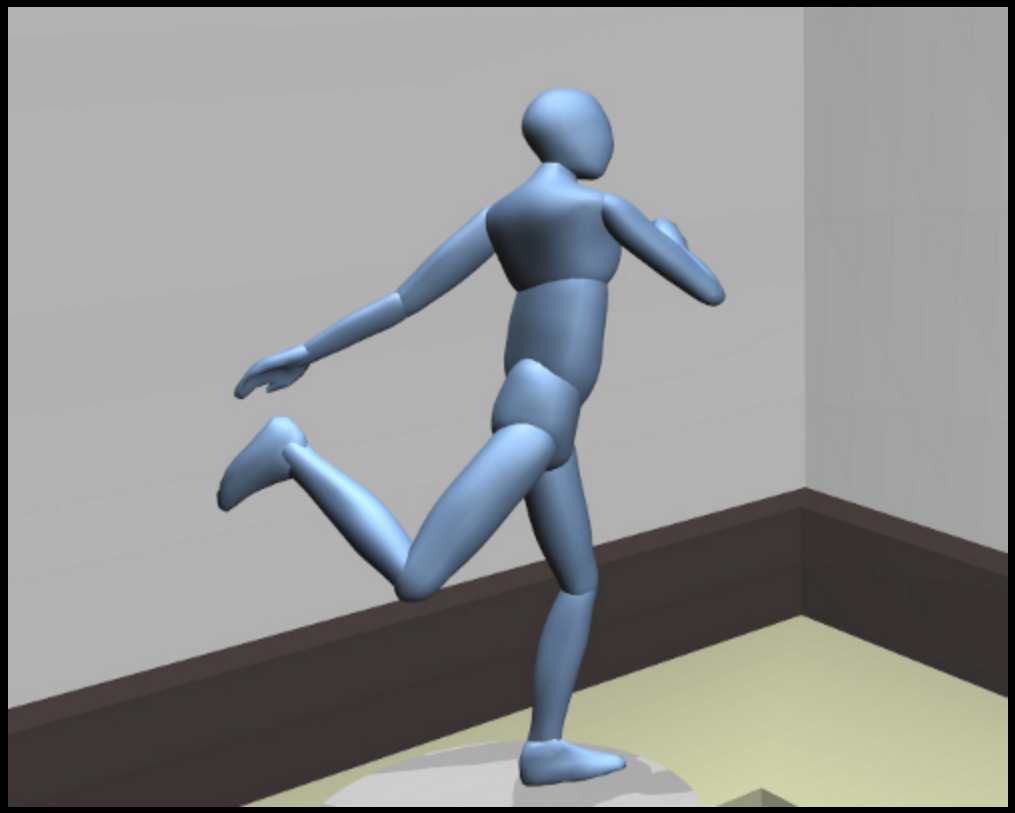
Physically-Based Simulation

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

Interactive Dynamic Response for Games
Zordan, V.B., Macchietto, A., Medina, J., Soriano, M., Wu, C.C.
ACM SIGGRAPH Sandbox Symposium 2007

Physically-Based Simulation

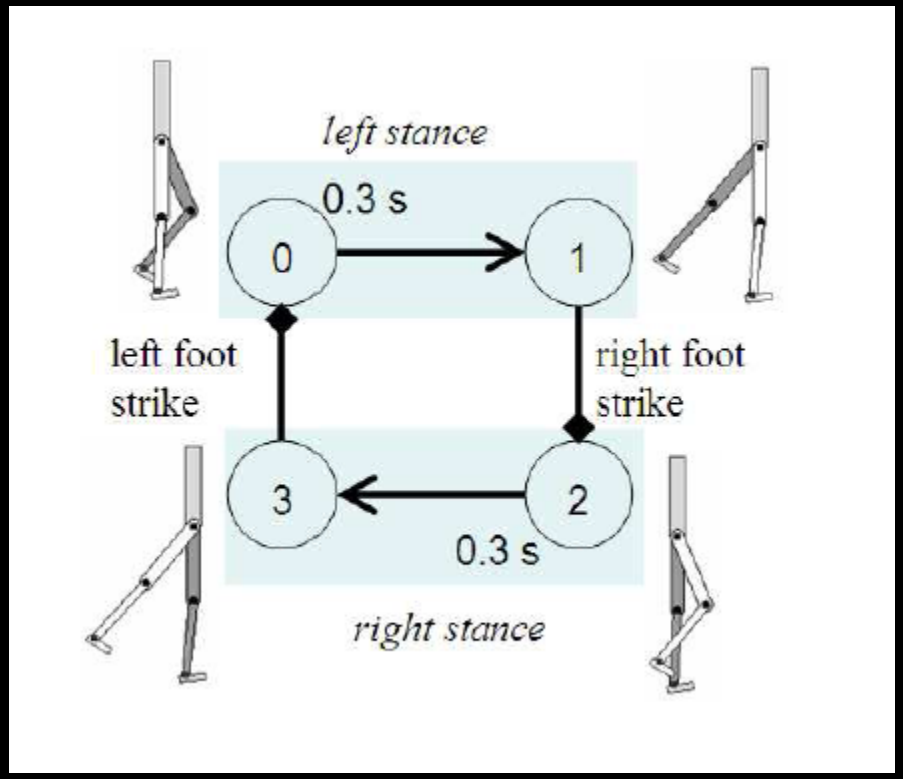
Physically-based simulation is also great for standing balance



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

Physically-Based Simulation

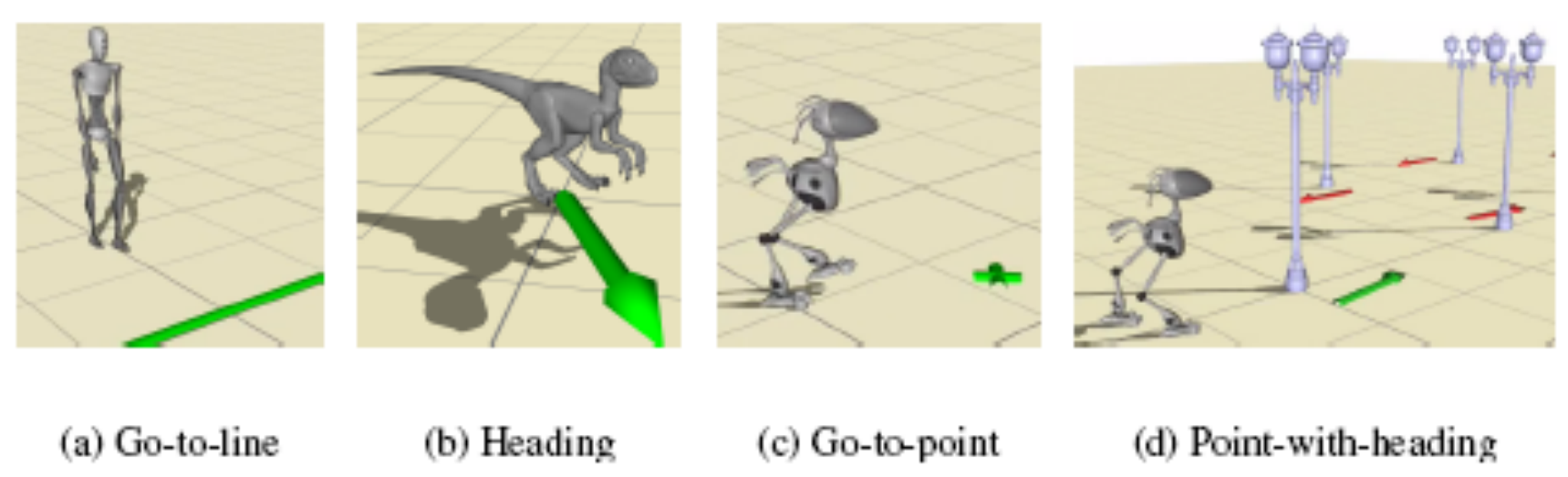
Pose-control graphs combined with dynamic simulation are making a powerful comeback recently



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

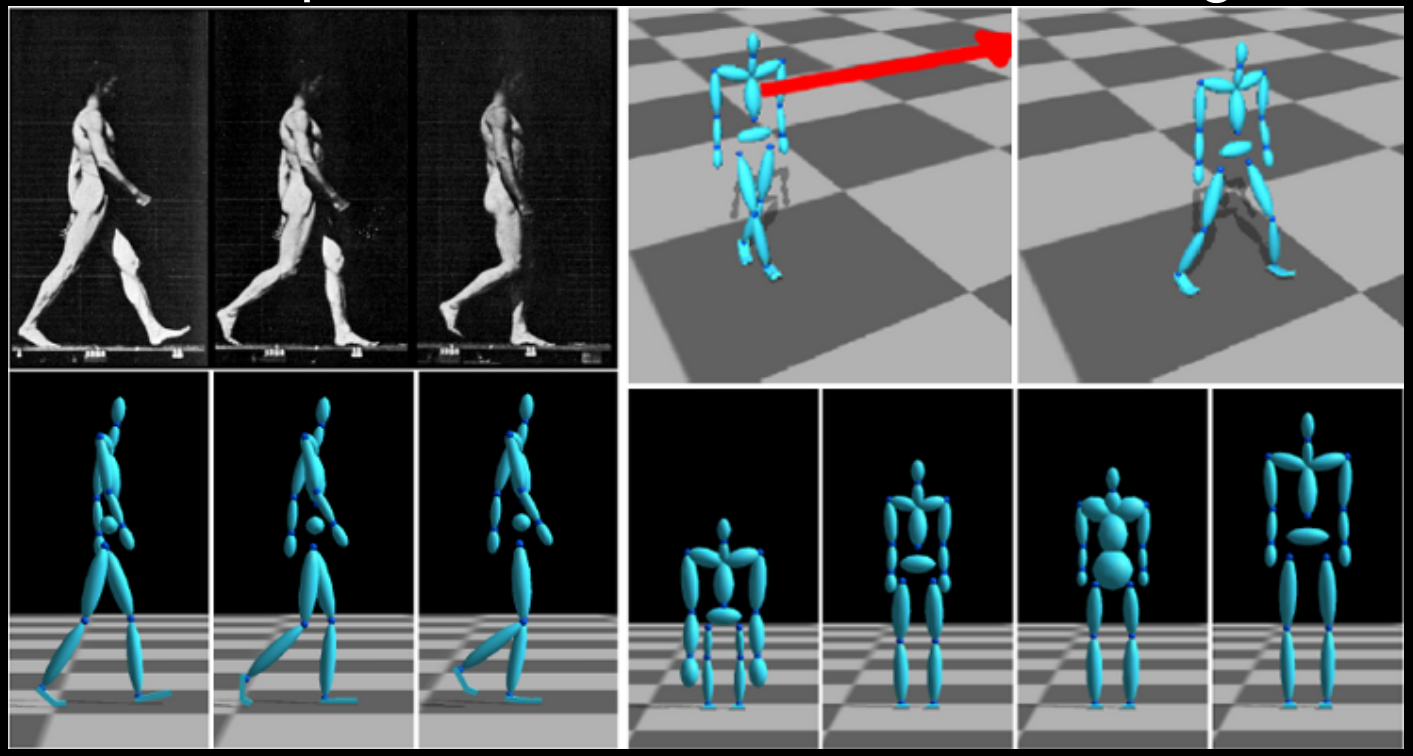
Van de Panne's group combines their own pose-based controllers with task-level information for characters than convey some level of intent



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

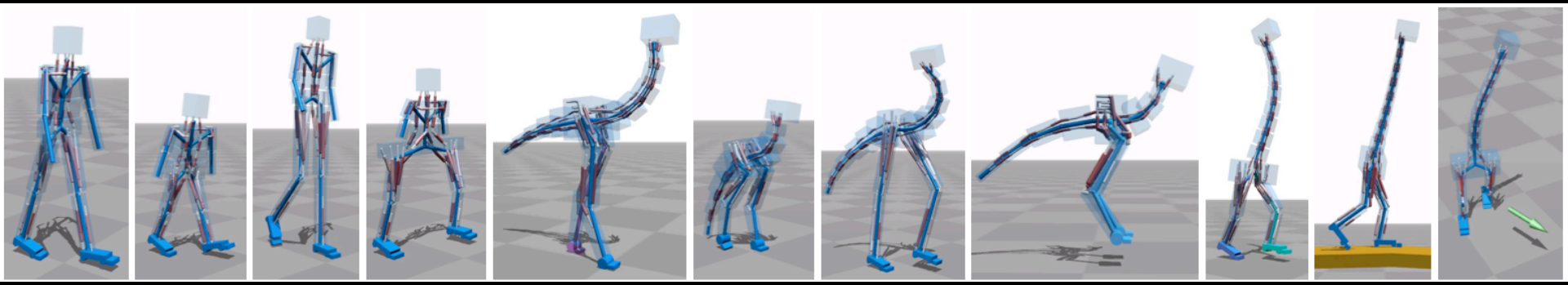
Herzmann's group augments pose-based controllers with optimization to produce more humanlike walking



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: Controllers using Muscle Models

However, maybe we really need muscles:

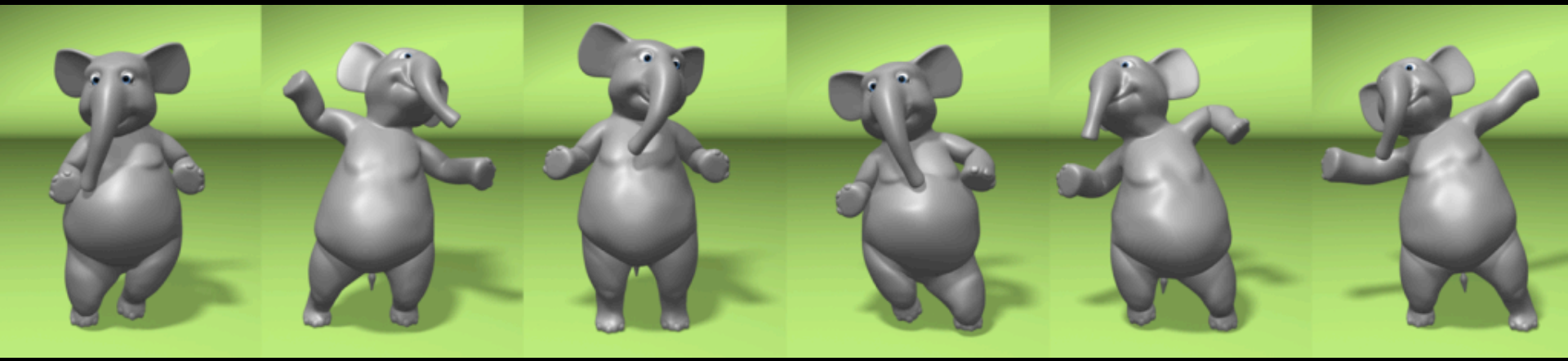


Flexible Muscle-Based Locomotion for Bipedal Creatures
Geijtenbeek, T., van de Panne, M. & Stappen, A.F. van der (2013)
In ACM Transactions on Graphics, Vol. 32, No. 6.

http://www.goatstream.com/research/papers/SA2013/index.html

Physically-Based Simulation: Physics based deformation

Recent research shows how finite element techniques can fit into the workflow of the artist



Hahn, Fabian, Sebastian Martin, Bernhard Thomaszewski, Robert Sumner, Stelian Coros, and Markus Gross. "Rig-space physics." ACM Transactions on Graphics (TOG) 31, no. 4 (2012): 72.

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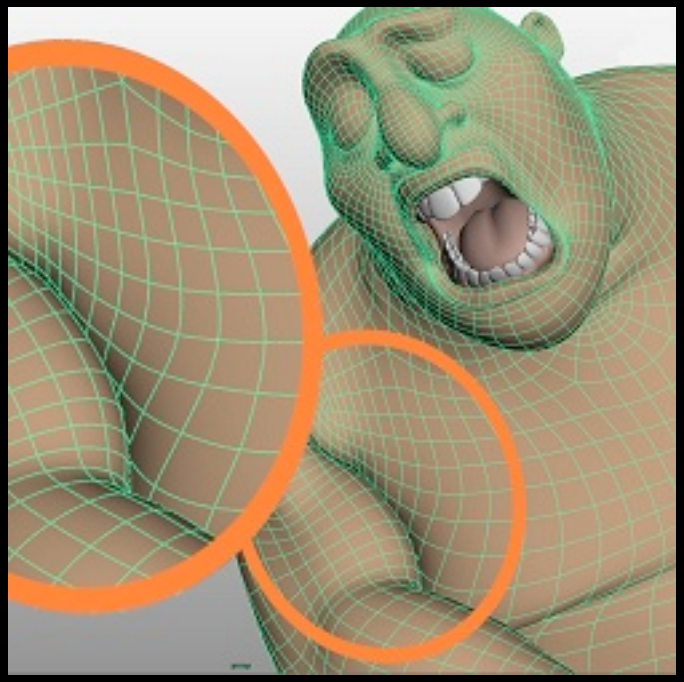


Efficient elasticity for character skinning with contact and collisions
A. McAdams, Y. Zhu, A. Selle, M. Empey, R. Tamstorf, J. Teran and E. Sifakis
ACM Transactions on Graphics (SIGGRAPH 2011), 30(4), pp.37:1-37:12, 2011

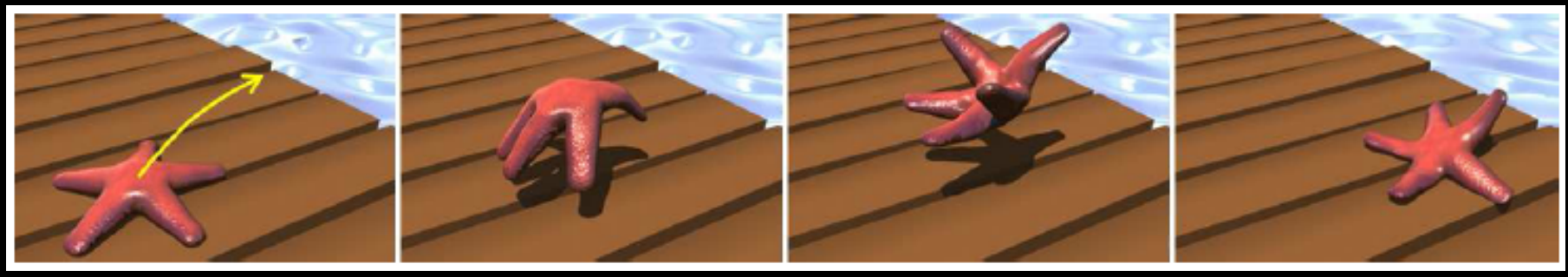
Artist Tools for Animation

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

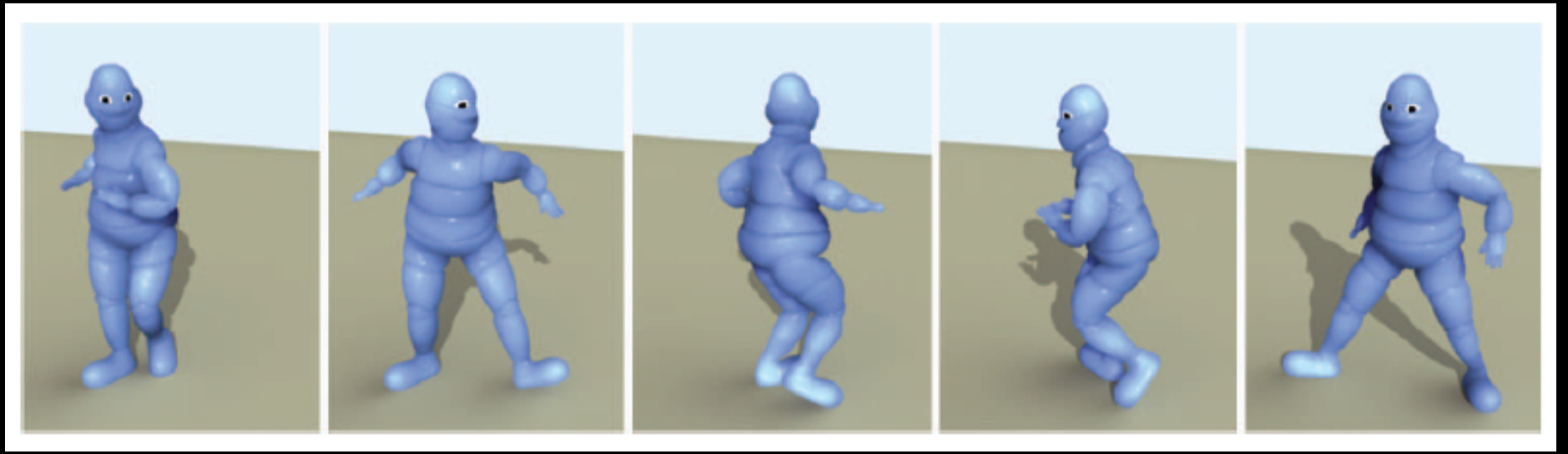
We are working to create direct control of a running simulation



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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