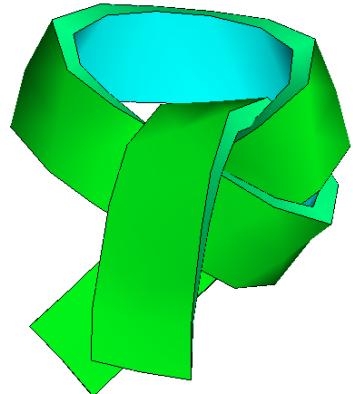
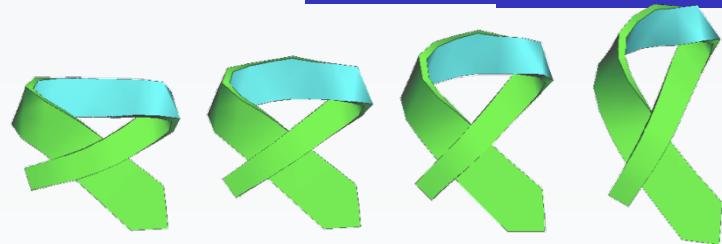
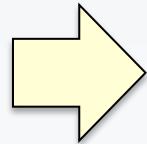


Week 4

Deformation and Animation



Deformation and Animation

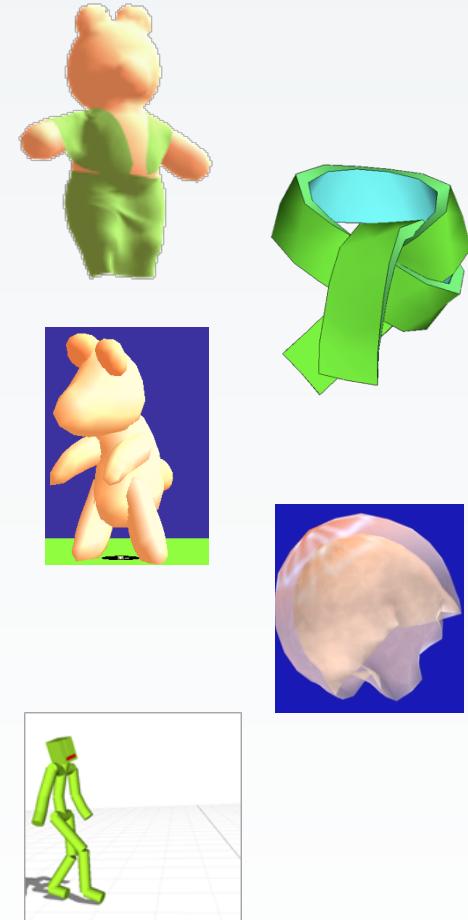


Static 3D shape
“Rigid”

Dynamic 3D shape
“Articulated / Soft”

Deformation and Animation

- Clothing Manipulations
- Layer Operations
- Spatial Key Framing
- Procedural Deformation
- Motion Database



Deformation and Animation



- Clothing Manipulations
- Layer Operations
- Spatial Key Framing
- Procedural Deformation
- Motion Database

Clothing Manipulation

*What do you want
to wear today?*

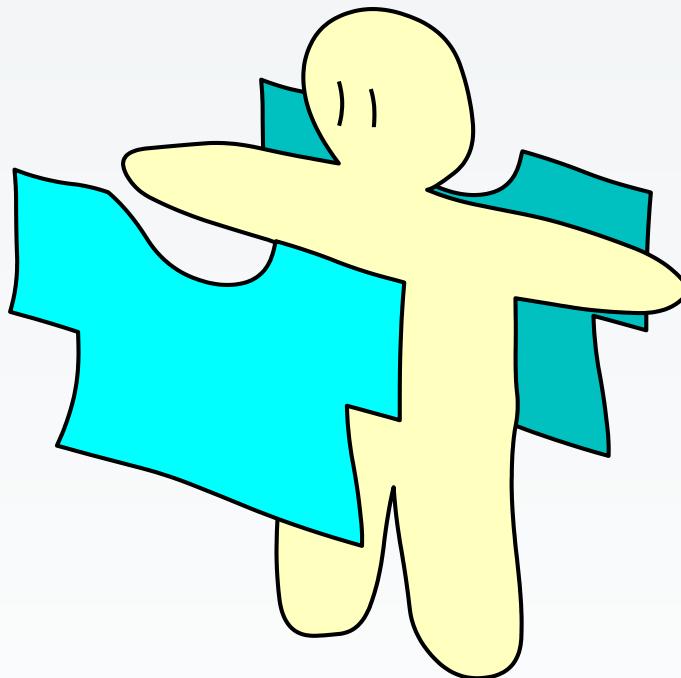


Takeo Igarashi
John F. Hughes
(Brown University)

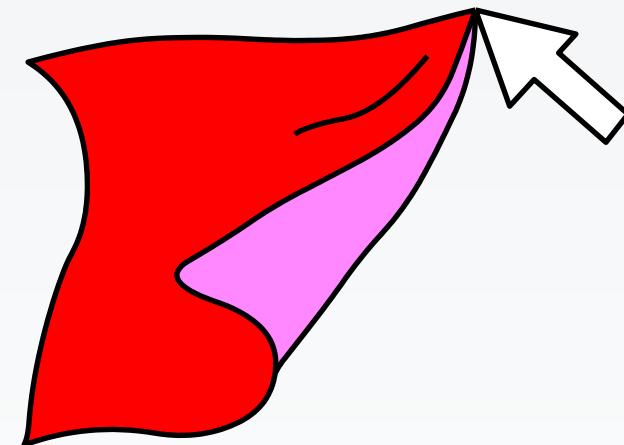
Problem

Cloth manipulation is difficult.

State of the Art

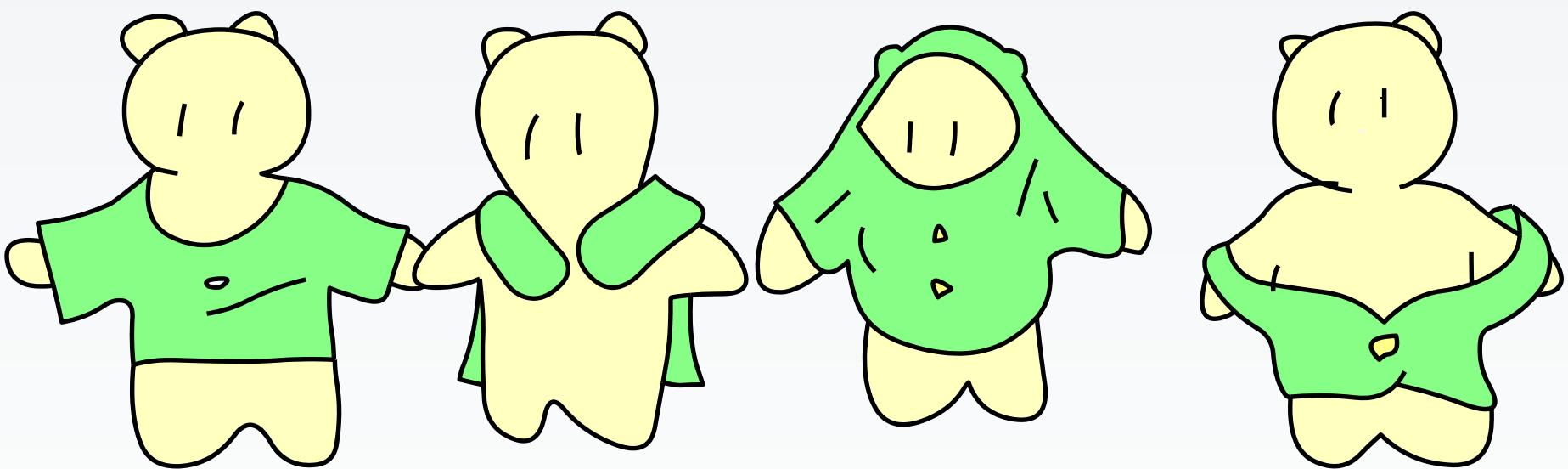


Drag rigid plates,
then start simulation



Drag a vertex with real-
time simulation

Targets



Putting cloth on characters in flexible ways.

DEMO!

cloth



THE UNIVERSITY OF TOKYO

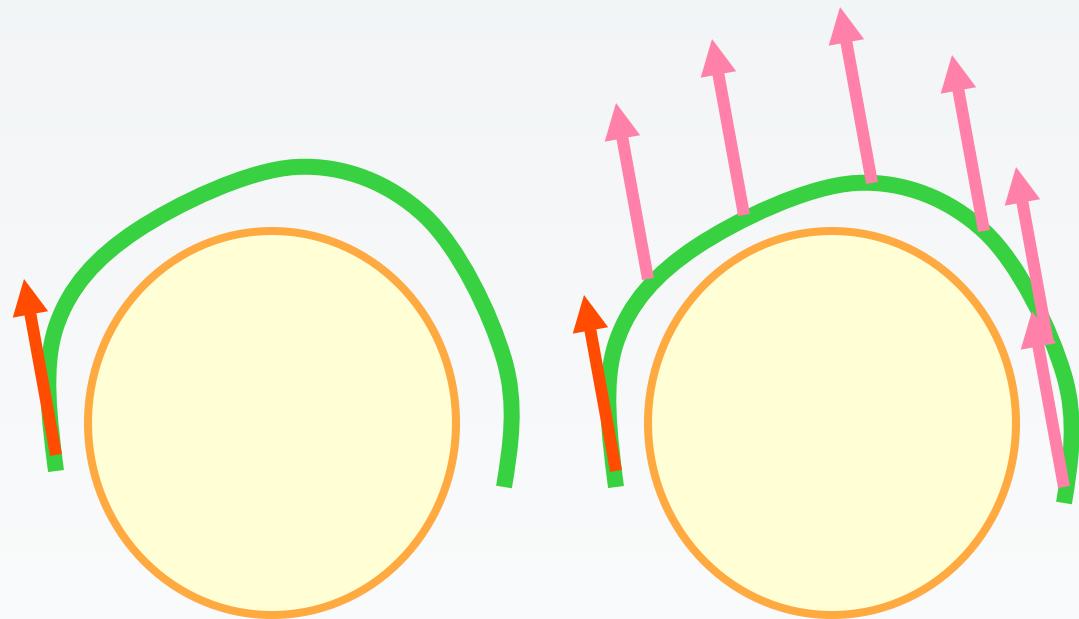
Video

cloth



THE UNIVERSITY OF TOKYO

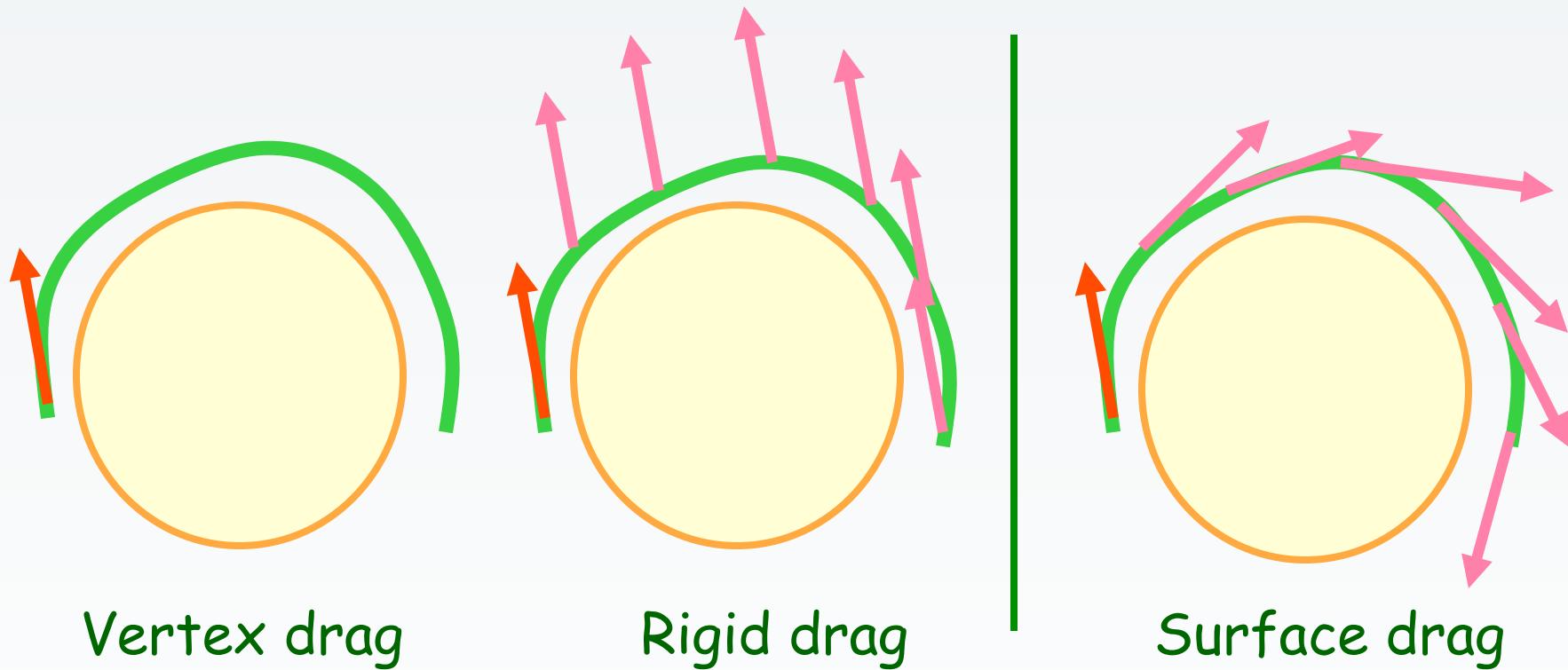
Surface Dragging



Vertex drag

Rigid drag

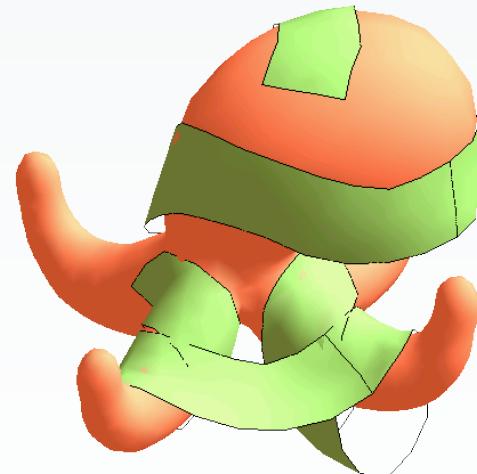
Surface Dragging



Propagate the mouse motion along the cloth surface.

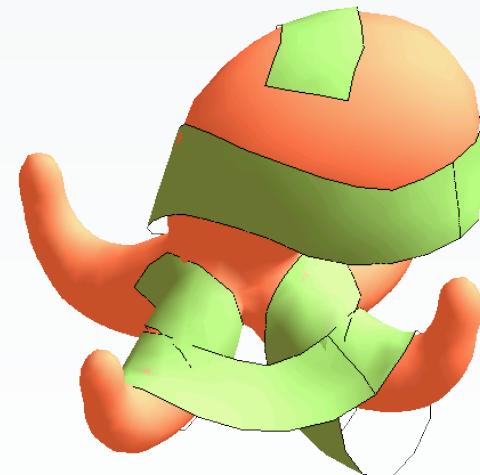
Implementation

- 1) Wrapping
- 2) Dragging

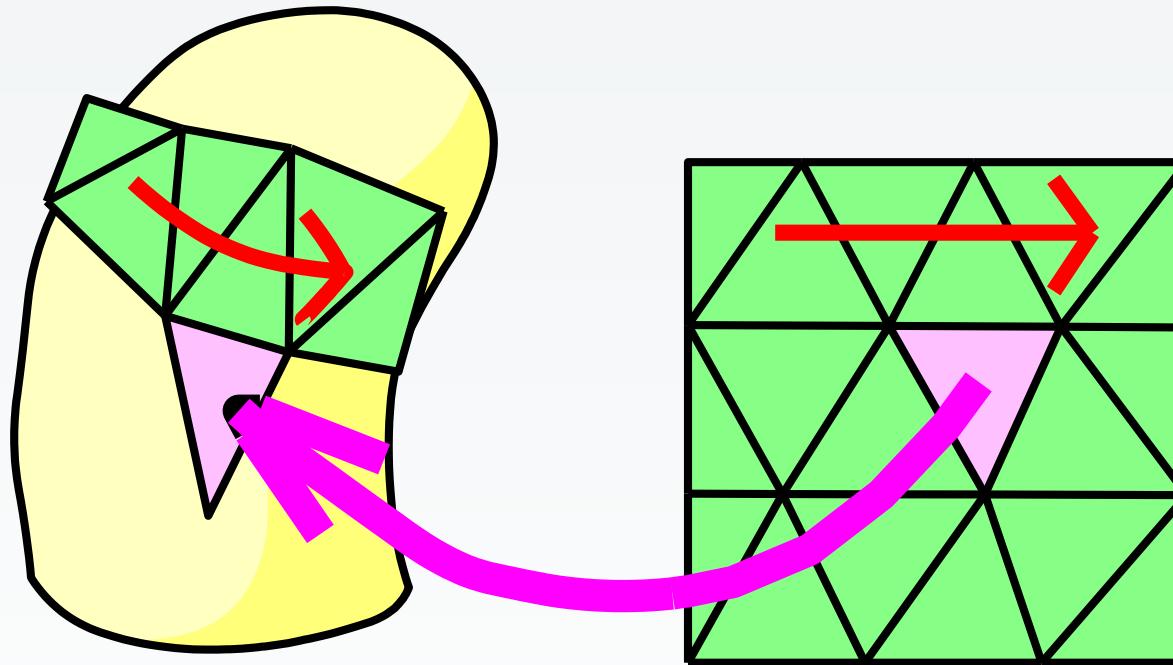


Implementation

- 1) Wrapping
2) Dragging

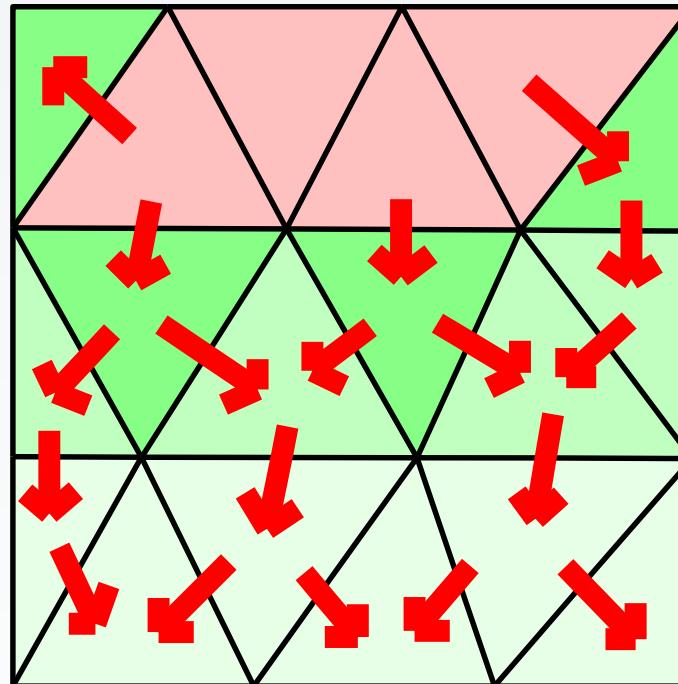


1) Wrapping



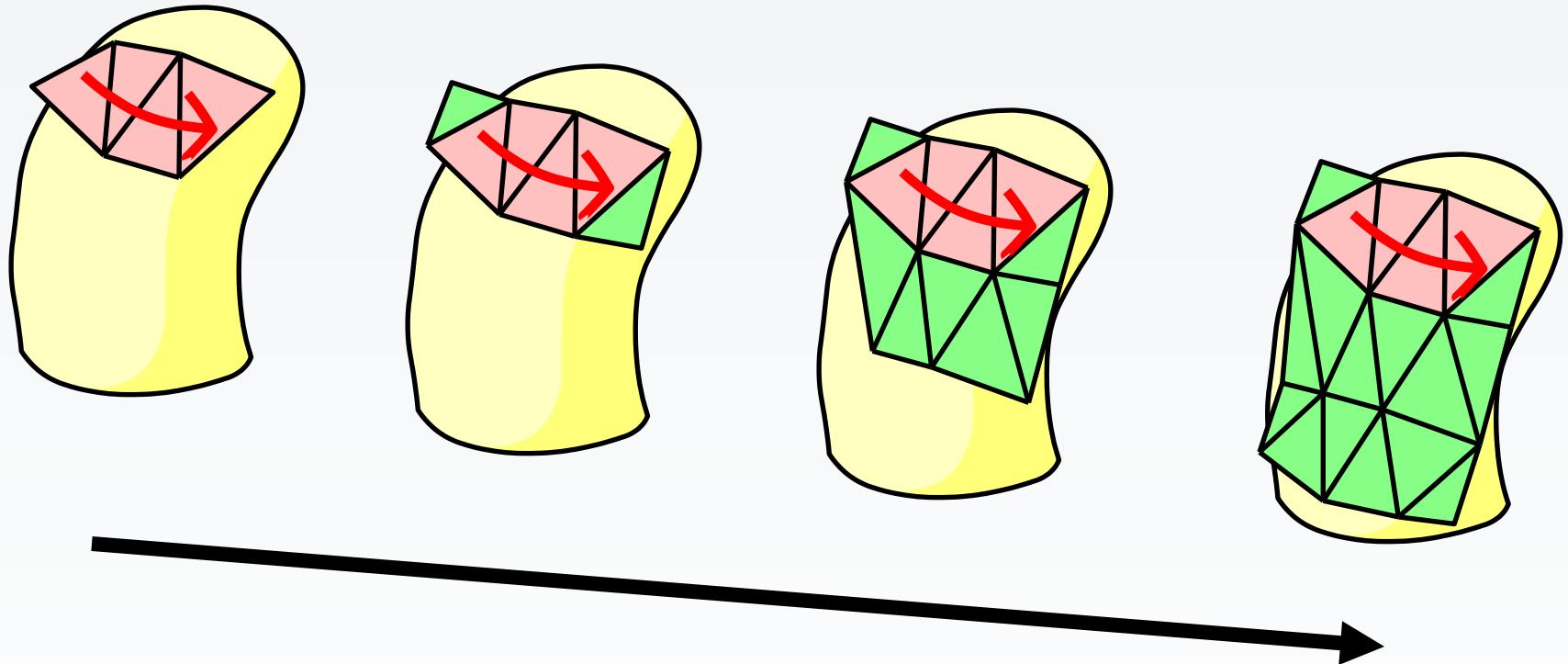
Paste triangles one by one

1) Wrapping



Compute the dependency graph.

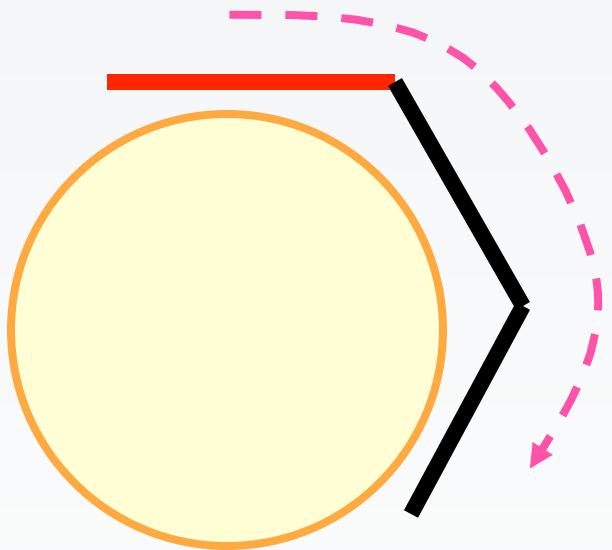
1) Wrapping



Paste the triangles
(grow the cloth)

1) Wrapping

Two possible approaches



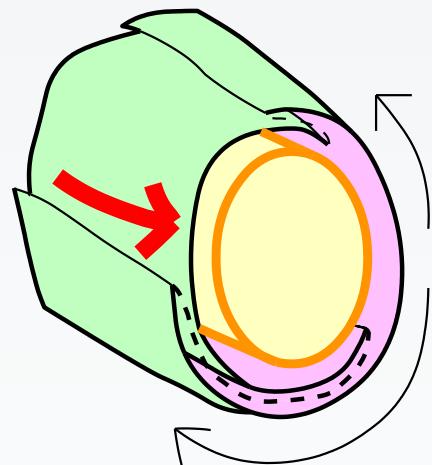
Stick to body



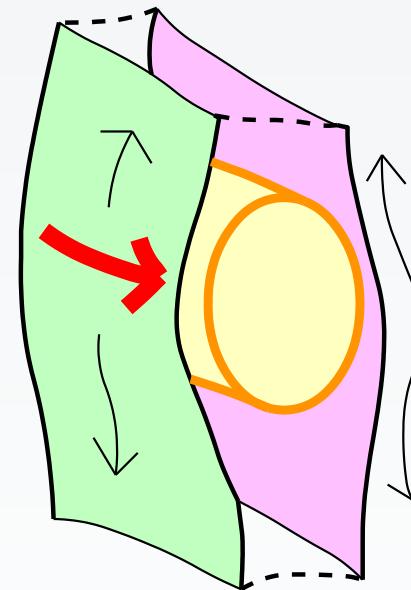
Planar growth
(our choice)

1) Wrapping

“stick to body” causes difficult folds.



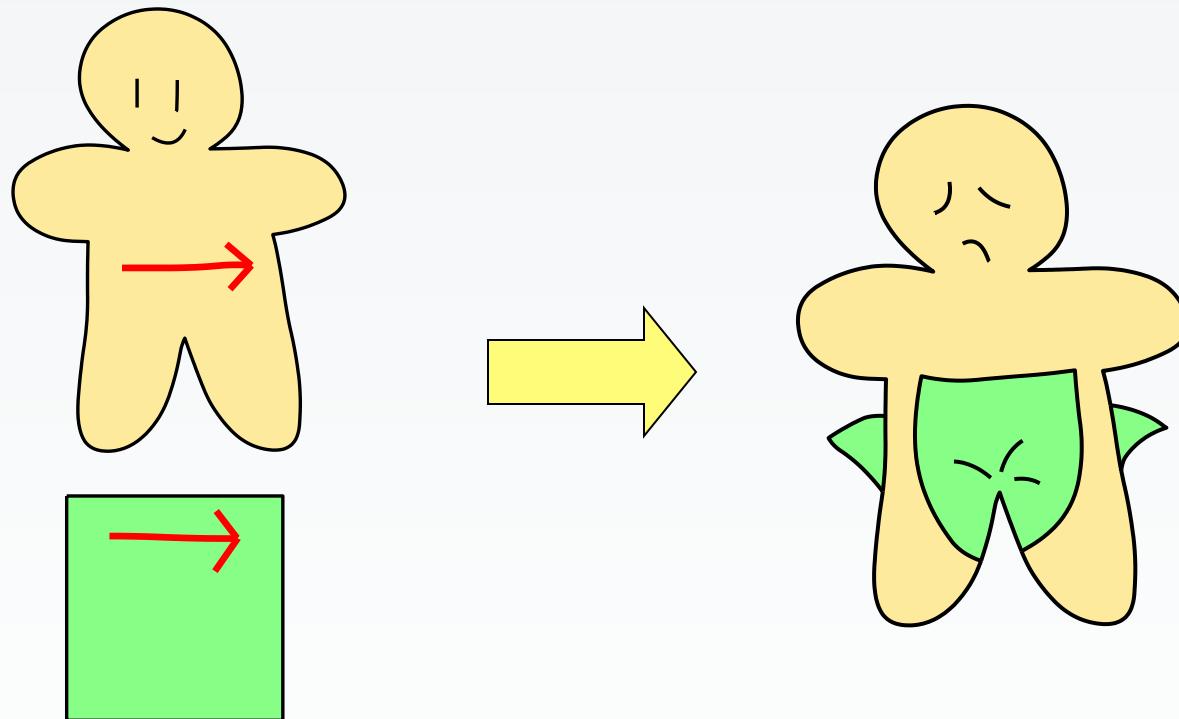
Stick to body



Planar growth
(our choice)

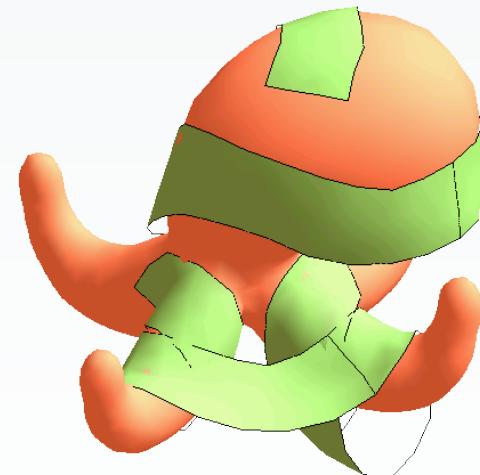
1) Wrapping

“stick to body” causes difficult folds.

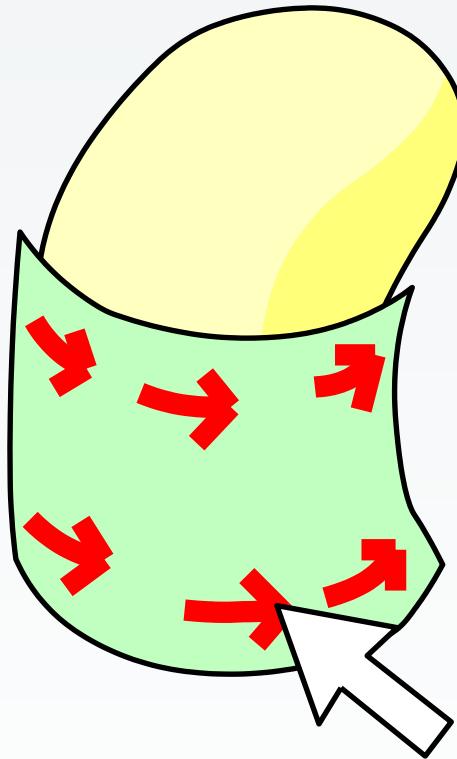


Implementation

- 1) Wrapping
2) Dragging

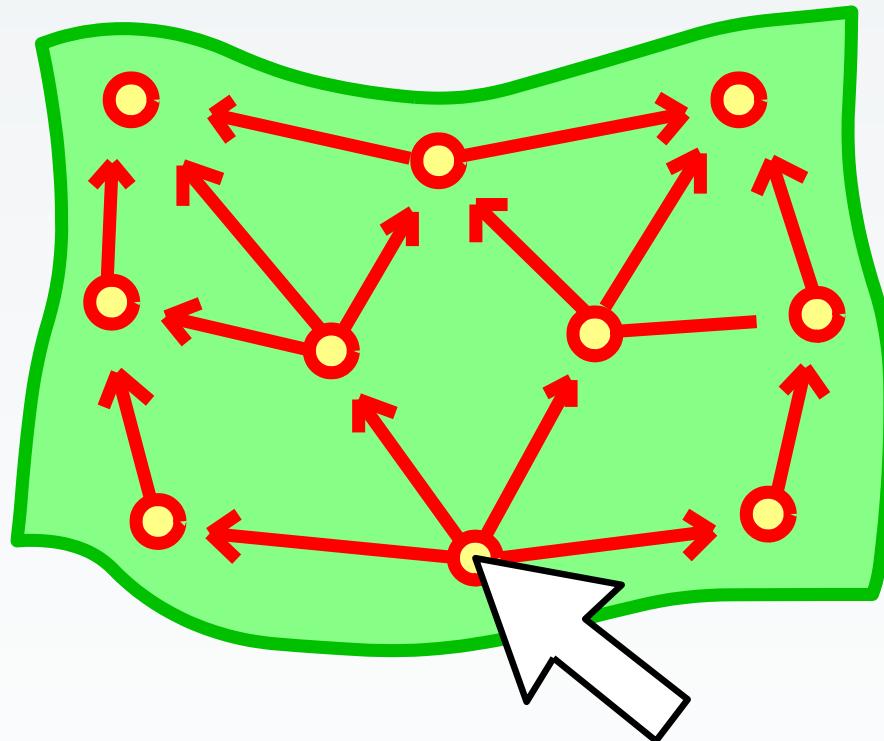


2) Dragging



Propagate the motion along the body.

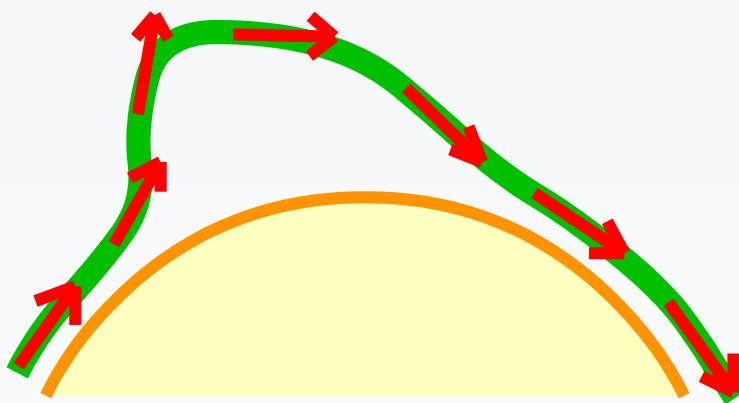
2) Dragging



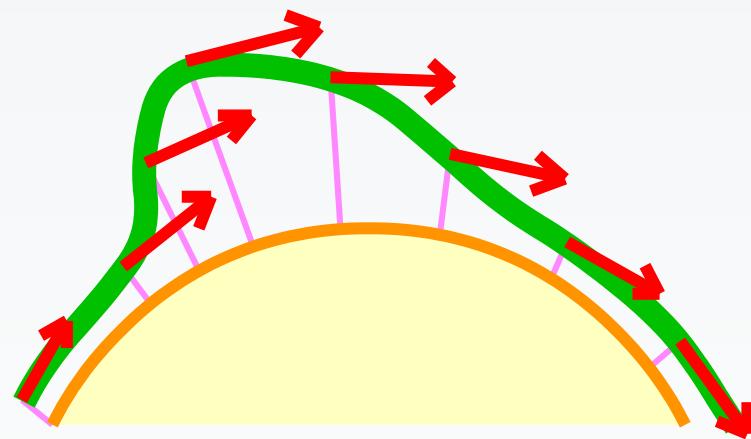
Compilation : pre-compute the dependency graph at Mouse-down.

2) Dragging

Two possible approaches



Based on cloth



Based on body
(our choice)

Summary

Clothing manipulation methods

- Painting interface for wrapping
- On-surface dragging

Implementation

- Growing the cloth on the body
- Propagating the motion on the body

To Learn More...

The original paper:

- Igarashi and Hughes. Clothing Manipulation. UIST 2002.

Cloth Simulation:

- Baraff and Witkin. Large steps in cloth simulation. SIGGRAPH 1998.

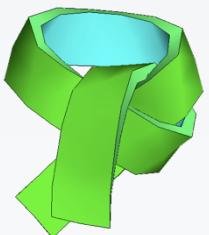


[Baraff and Witkin 1998]

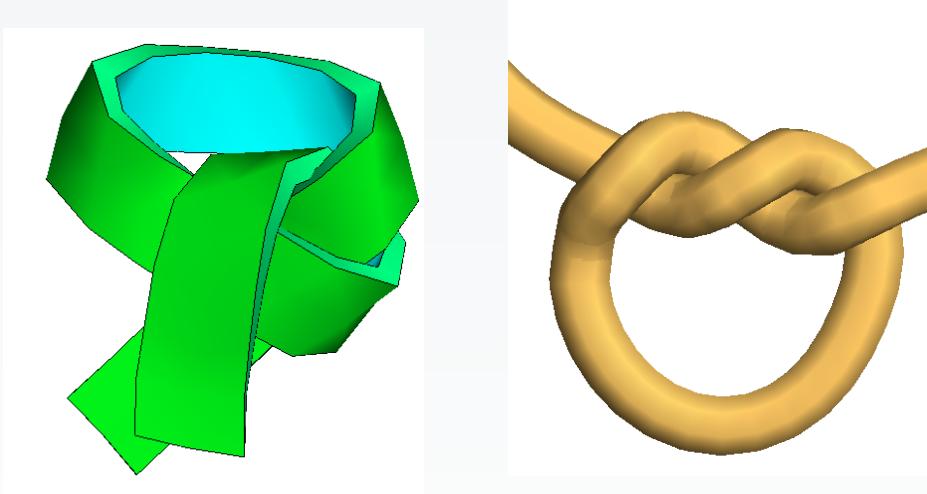
Copyright 1998 ACM. Included here by permission.

Deformation and Animation

- Clothing Manipulations
- Layer Operations
- Spatial Key Framing
- Procedural Deformation
- Motion Database



Apparent Layer Operations for the Manipulation of Deformable Objects

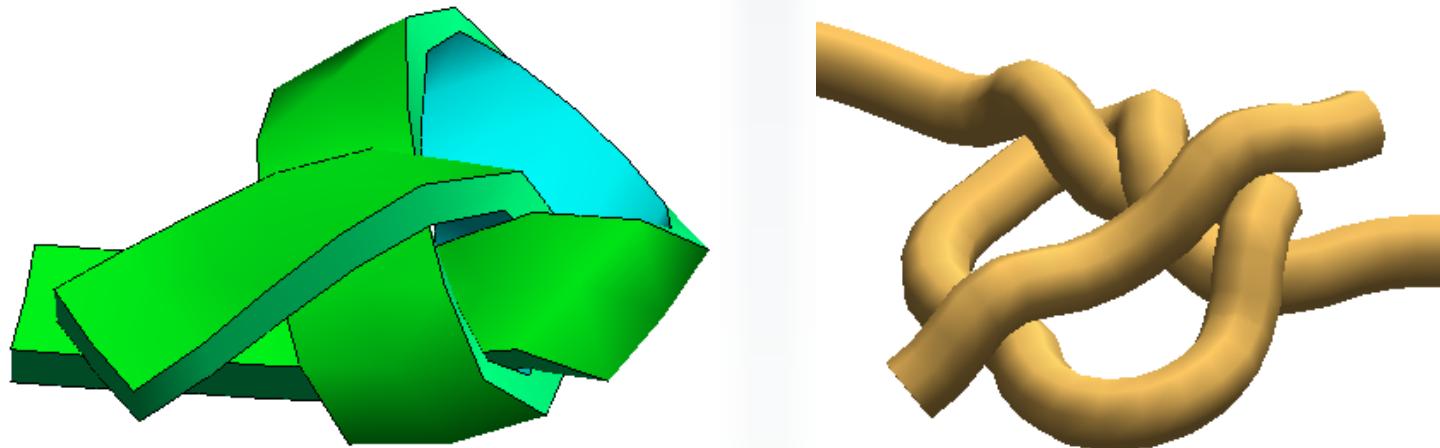


Takeo Igarashi Jun Mitani

JST ERATO Igarashi Design Interface Project

Motivation

Interaction with deformable objects

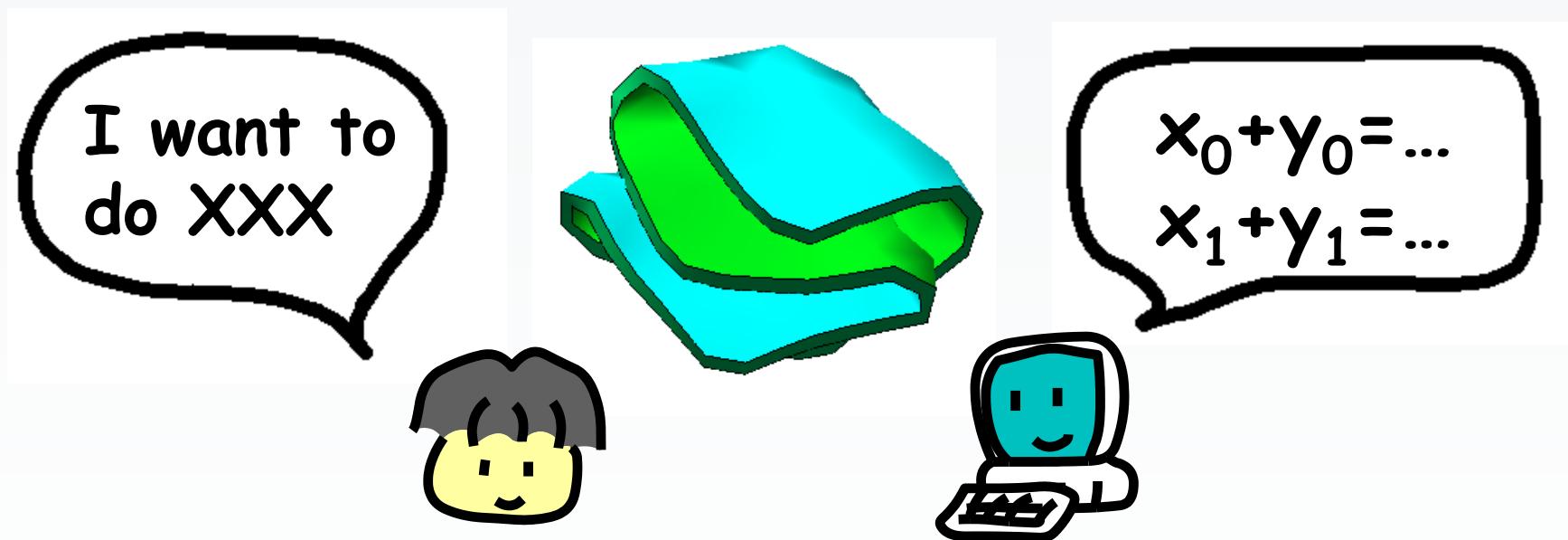


Physical simulation → Inflexible...

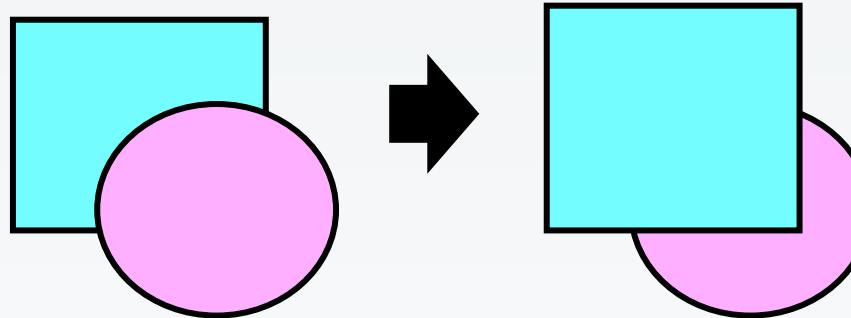
Direct manipulation → Tedious...

Motivation

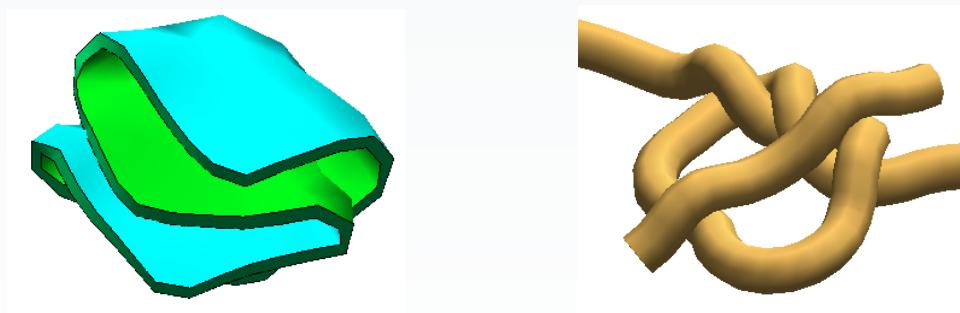
We introduce semantic-level operations.



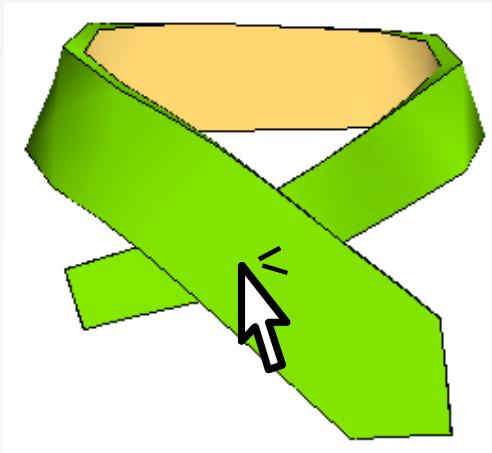
In this work, we introduce
layer operations



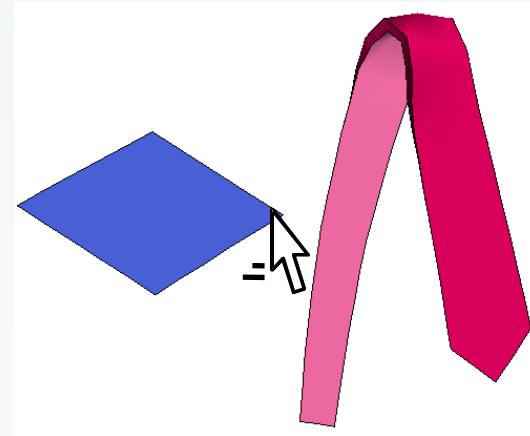
for 3D modeling



Contributions



layer swap



layer-aware drag

Interaction and algorithms

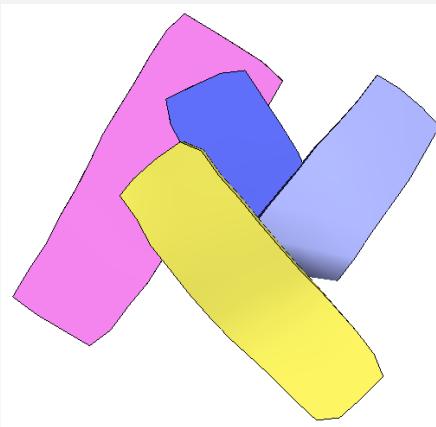
Demo

mesh

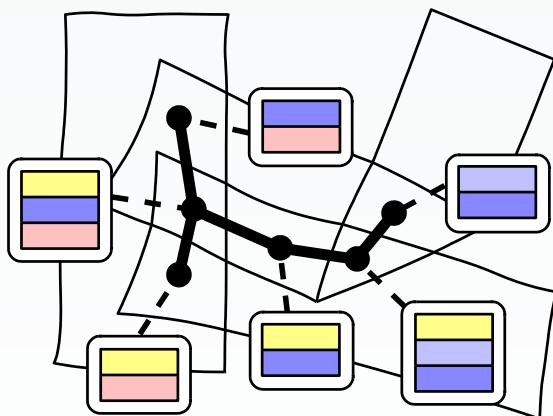
Algorithm

(layer swap)

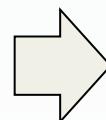
Before



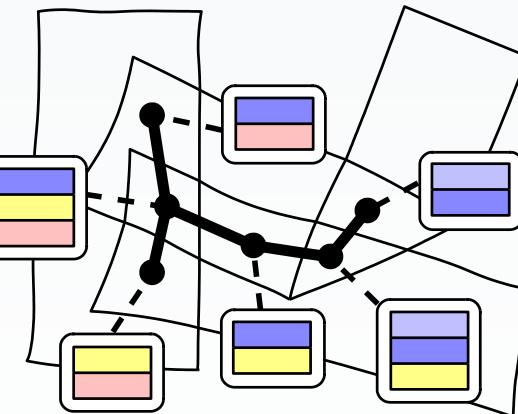
1. Project
& analyze



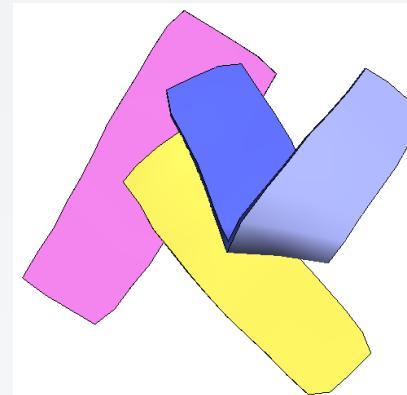
2. Swap



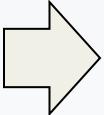
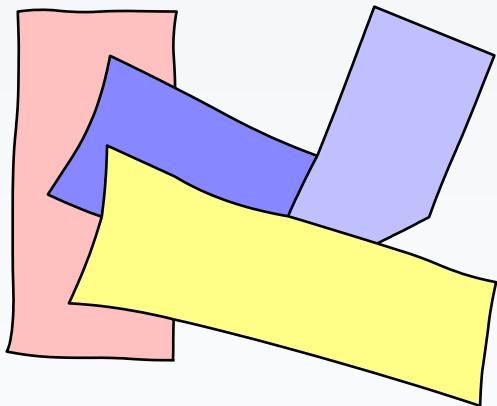
3. Synthesize
& relax



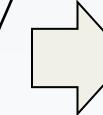
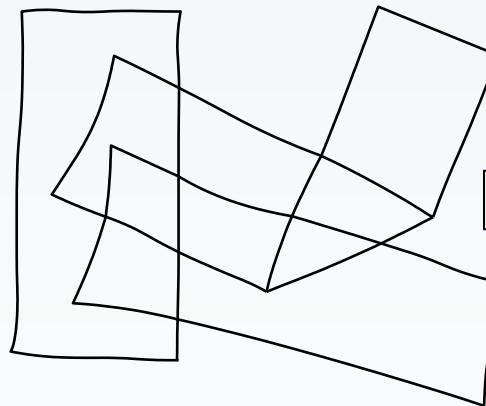
After



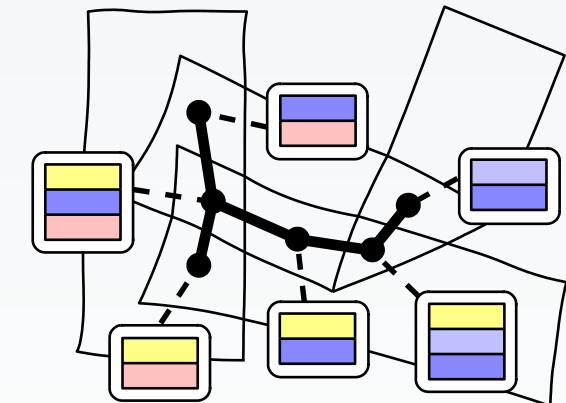
1. Project & Analyze



Project & segment



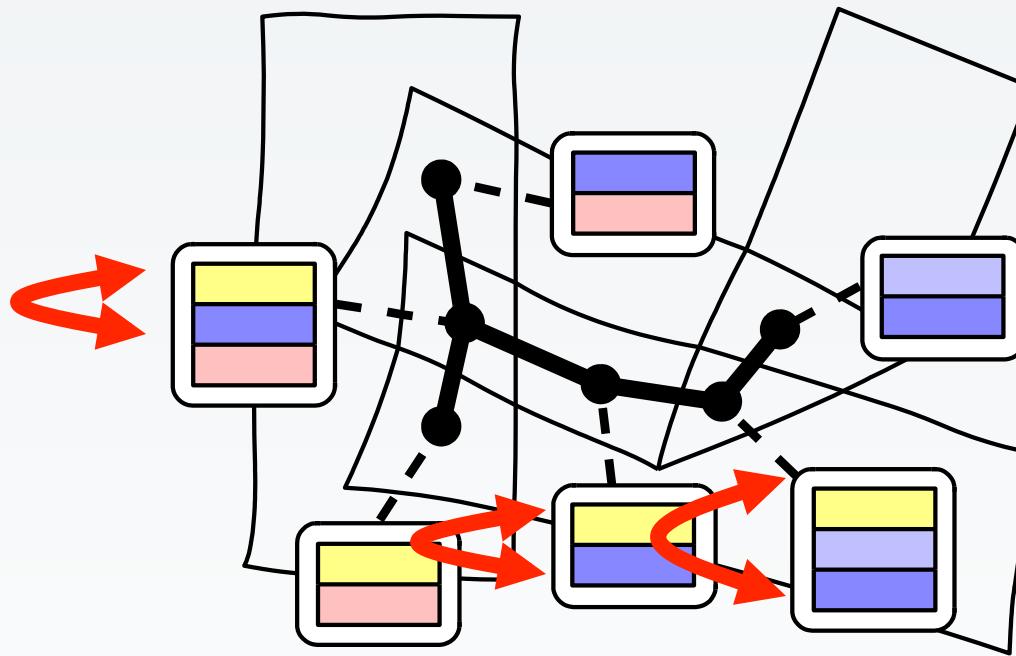
List graph construction



[Eisemann+ 2009]

[McCann+ 2009]

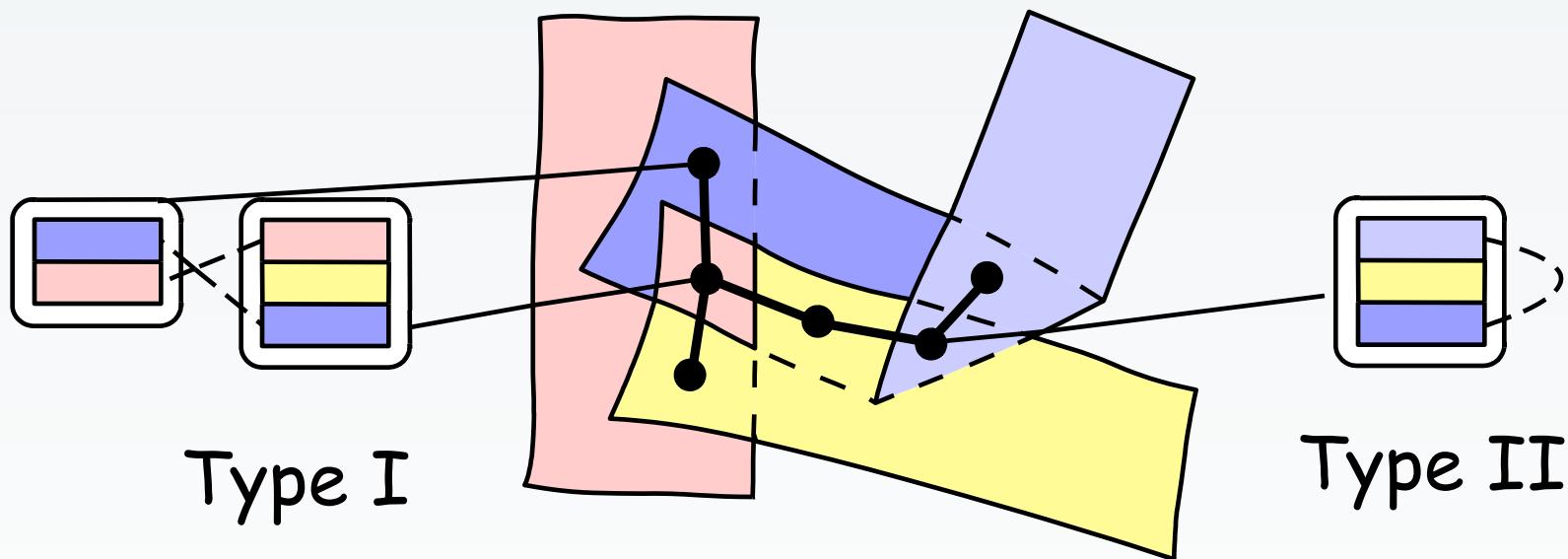
2. Swap layers



The system updates the list graph

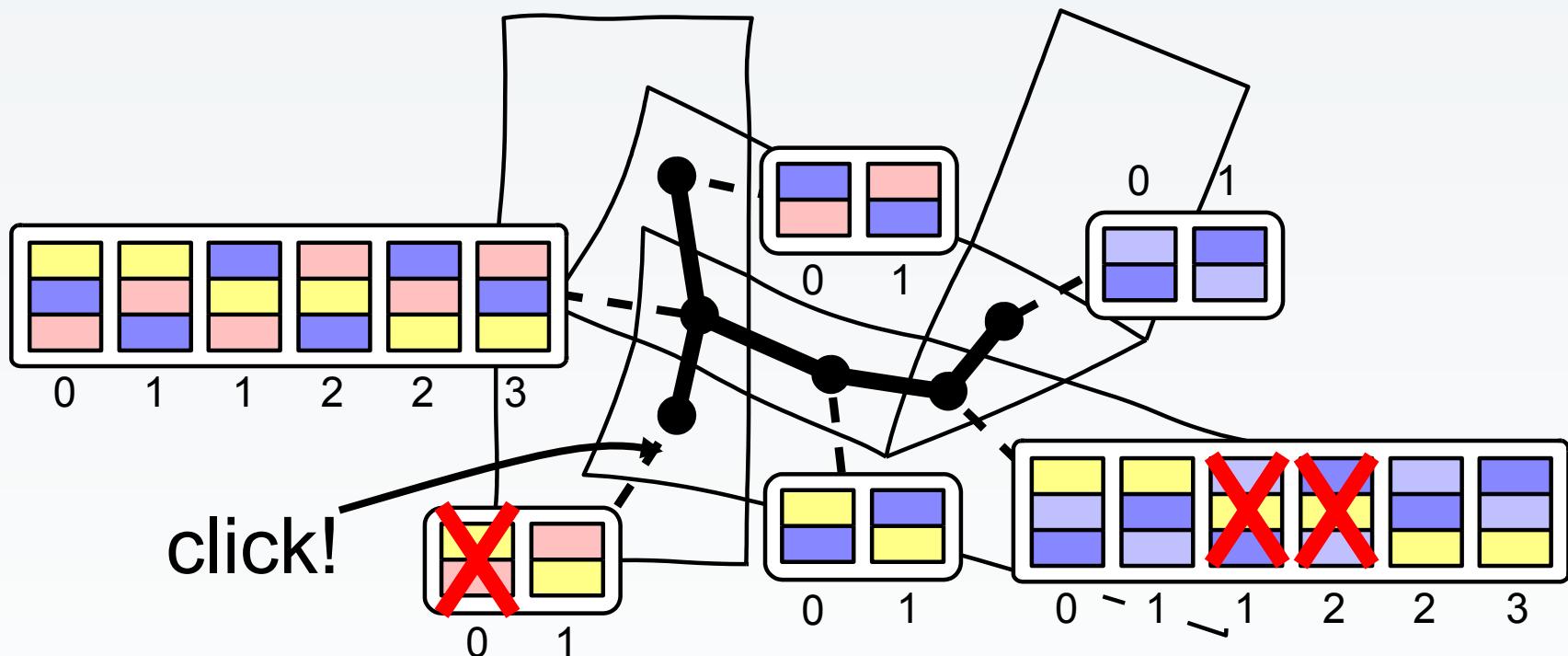
- satisfying user request (swaps layers)
- avoiding invalid configurations.

Invalid Configurations



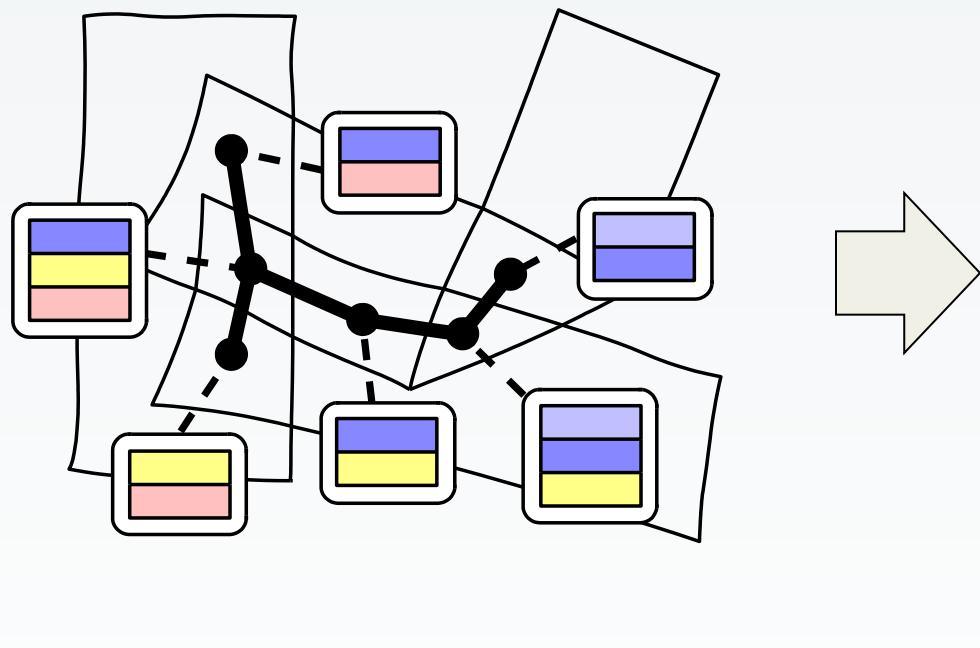
The system avoids these violations.

How to find valid layers?

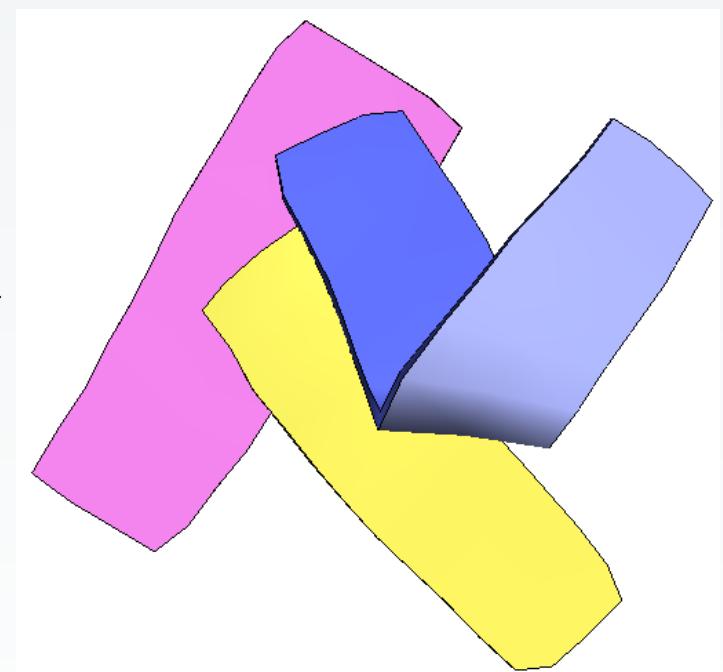


1. All permutations of layer orders in each region
2. Enumeration of valid combinations of them.

3. Synthesize & Relax

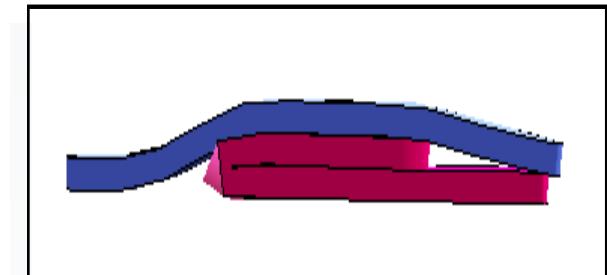
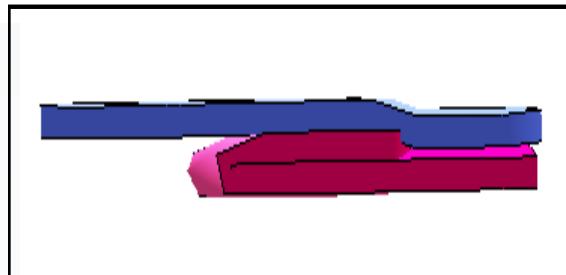
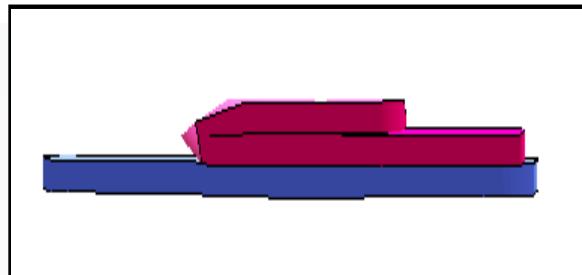
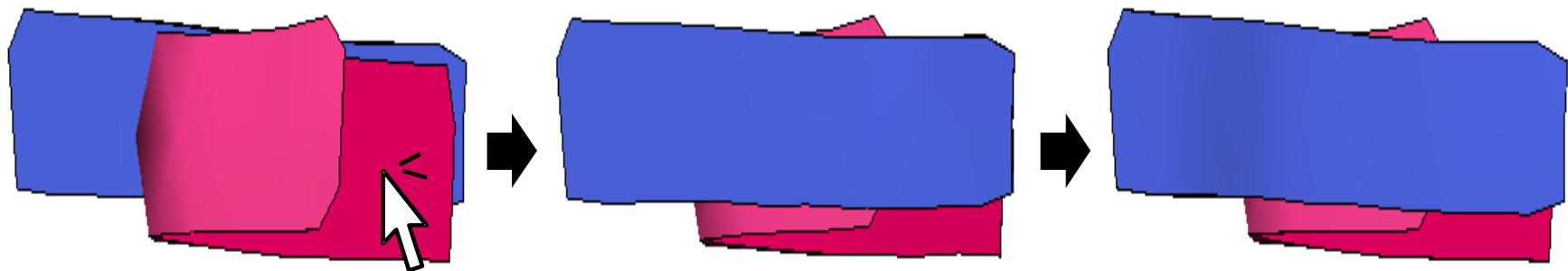


Updated list graph



Updated 3D scene

3. Synthesize & Relax



Geometric
computation

Physical
simulation

Summary

Layer operations for cloth and ropes.

- Layer swap
- Layer aware drag

Projection to 2.5D representation.

Project → Re-order → synthesize.

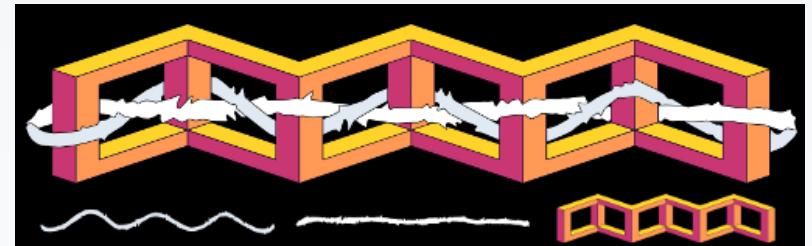
To Learn More...

The original paper:

- Igarashi and Mitani. Apparent Layer Operations for the Manipulation of Deformable Objects. SIGGRAPH 2010.

2D layer operations:

- McCann and Pollard. Local layering. SIGGRAPH 2009.



[McCann and Pollard 2009]

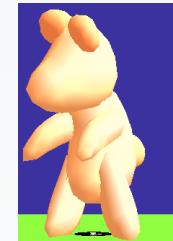
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3D to 2D projection:

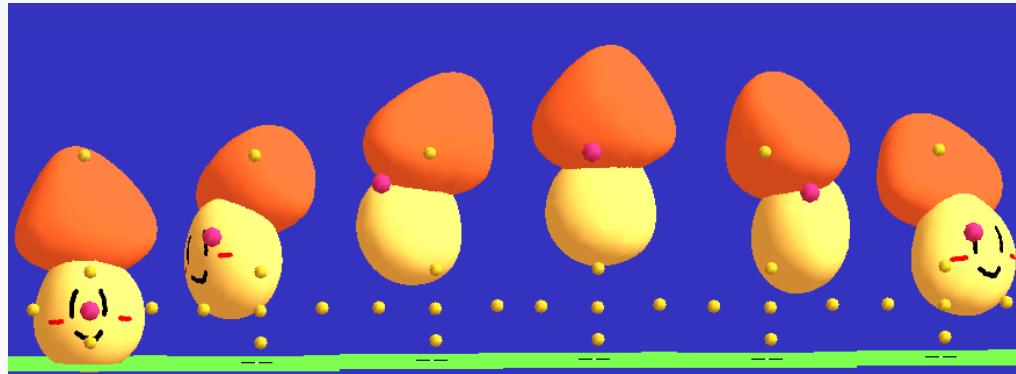
- Eiseman et al. Visibility algorithm for converting 3D meshes into editable 2D vector graphics. SIGGRAPH 2009.

Deformation and Animation

- Clothing Manipulations
- Layer Operations
- Spatial Key Framing
- Procedural Deformation
- Motion Database



Spatial Keyframing for Performance-driven Animation



Takeo Igarashi, Tomer Moscovich, John F. Hughes
The University of Tokyo, Brown University

Motivation

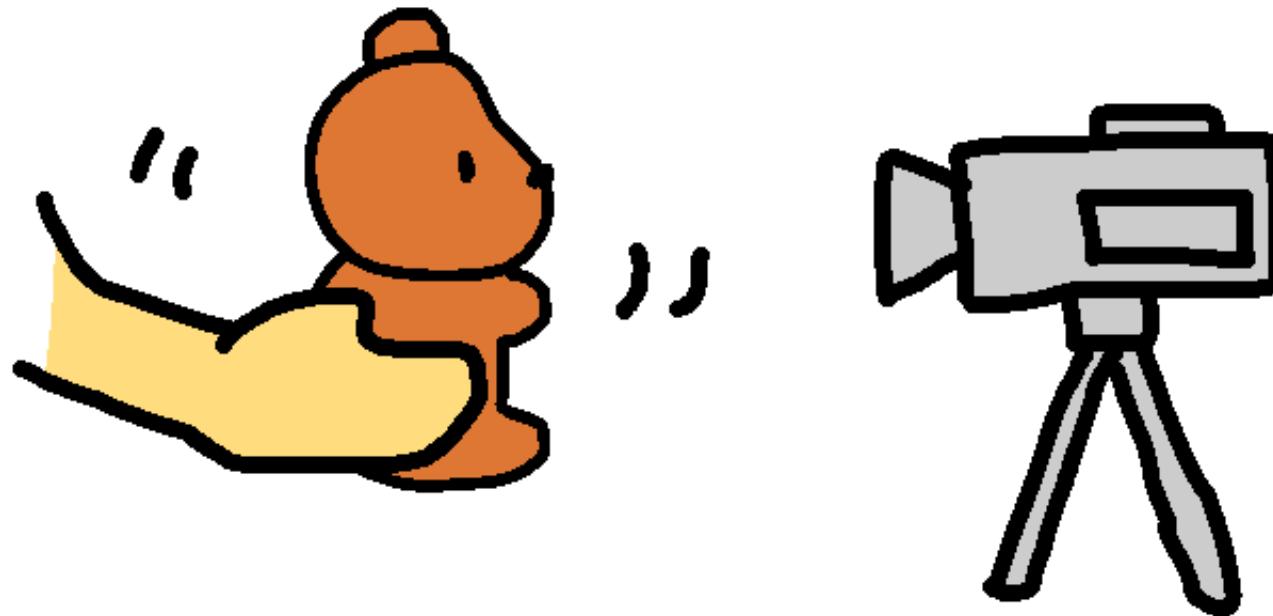
Creation of character animation is tedious.

- Keyframe
- Motion capture
- Physics simulation
- Scripting



We want to “sketch” animations quickly.

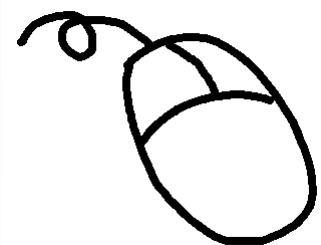
Basic idea



“To record the user’s direct operations”

Problem

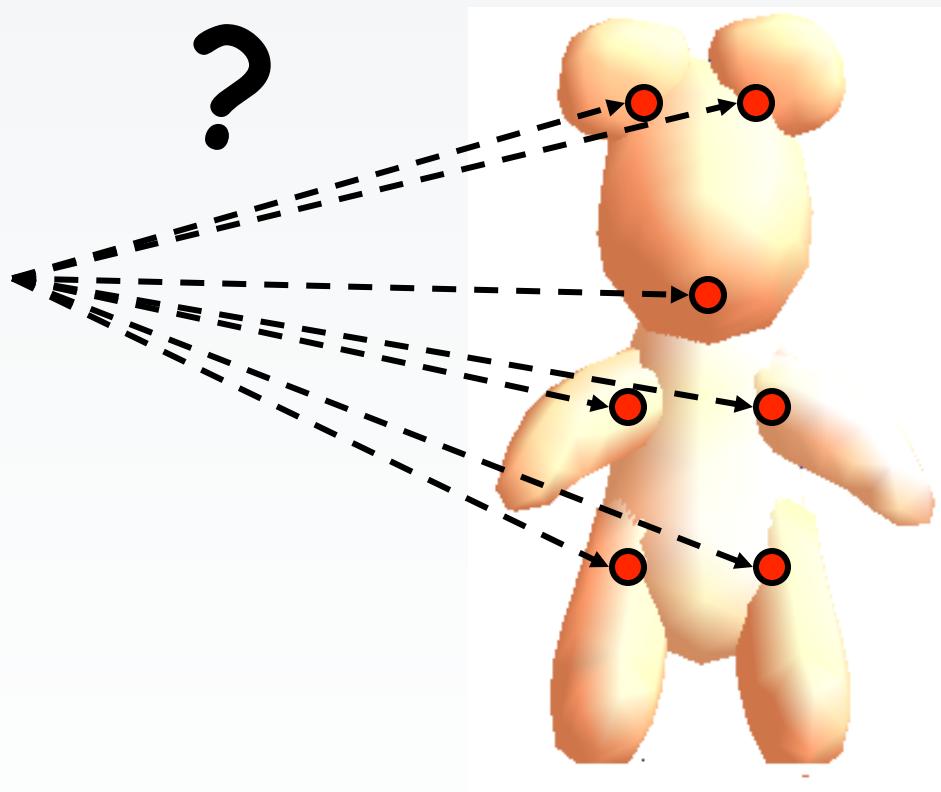
2D input



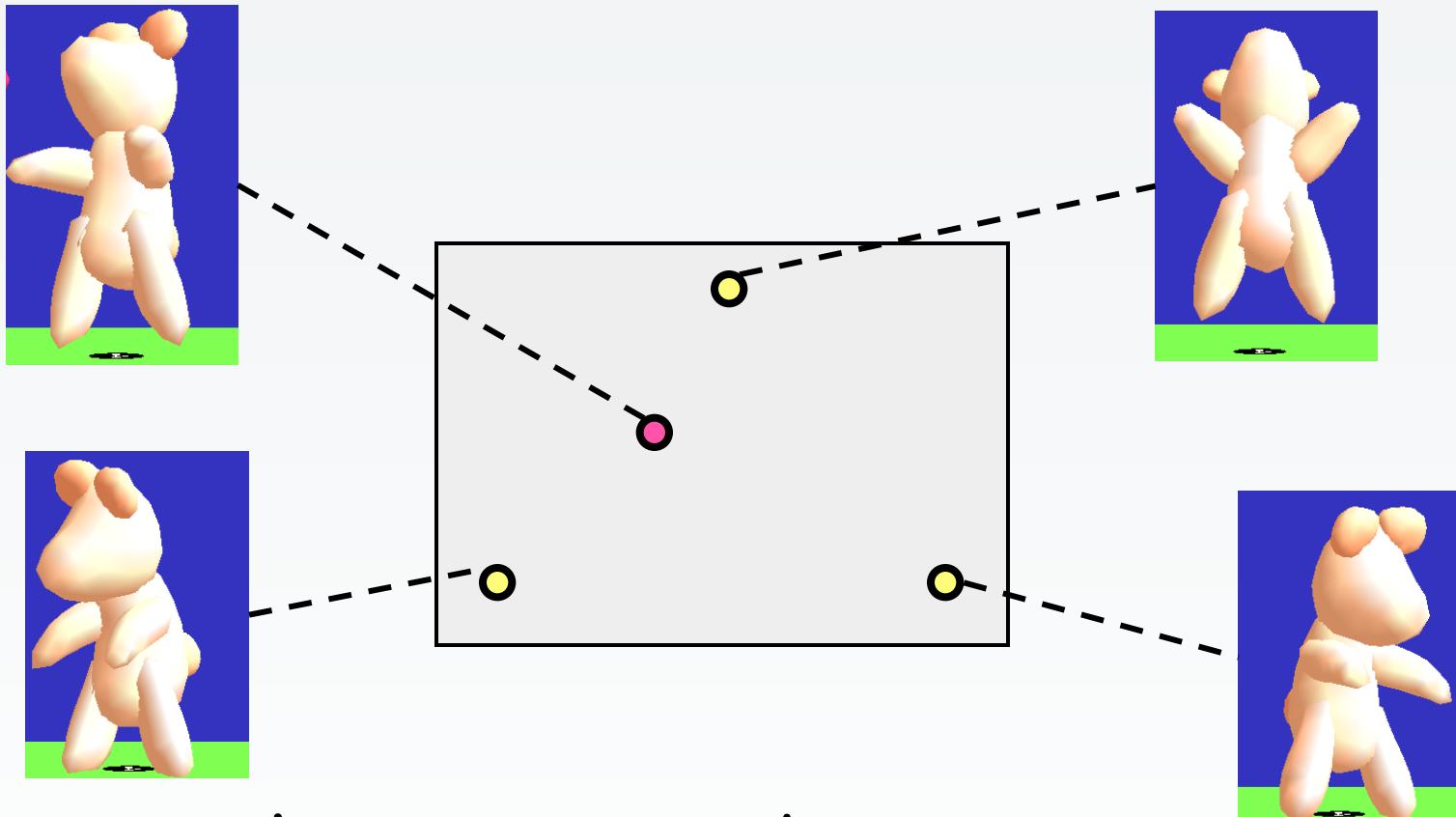
X and Y

?

High DOF

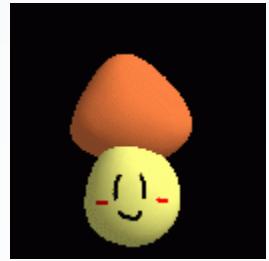
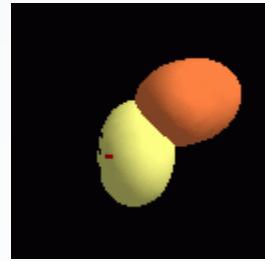
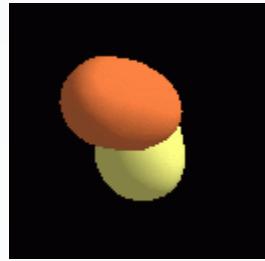
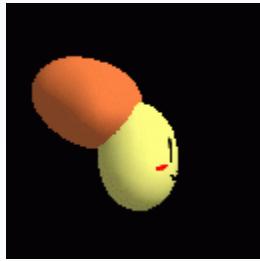
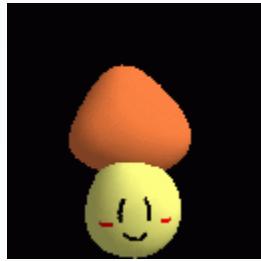


Spatial Keyframing



Prepare key poses and
blend them during performance

Demo



[squirrel](#)

Algorithm

Algorithm

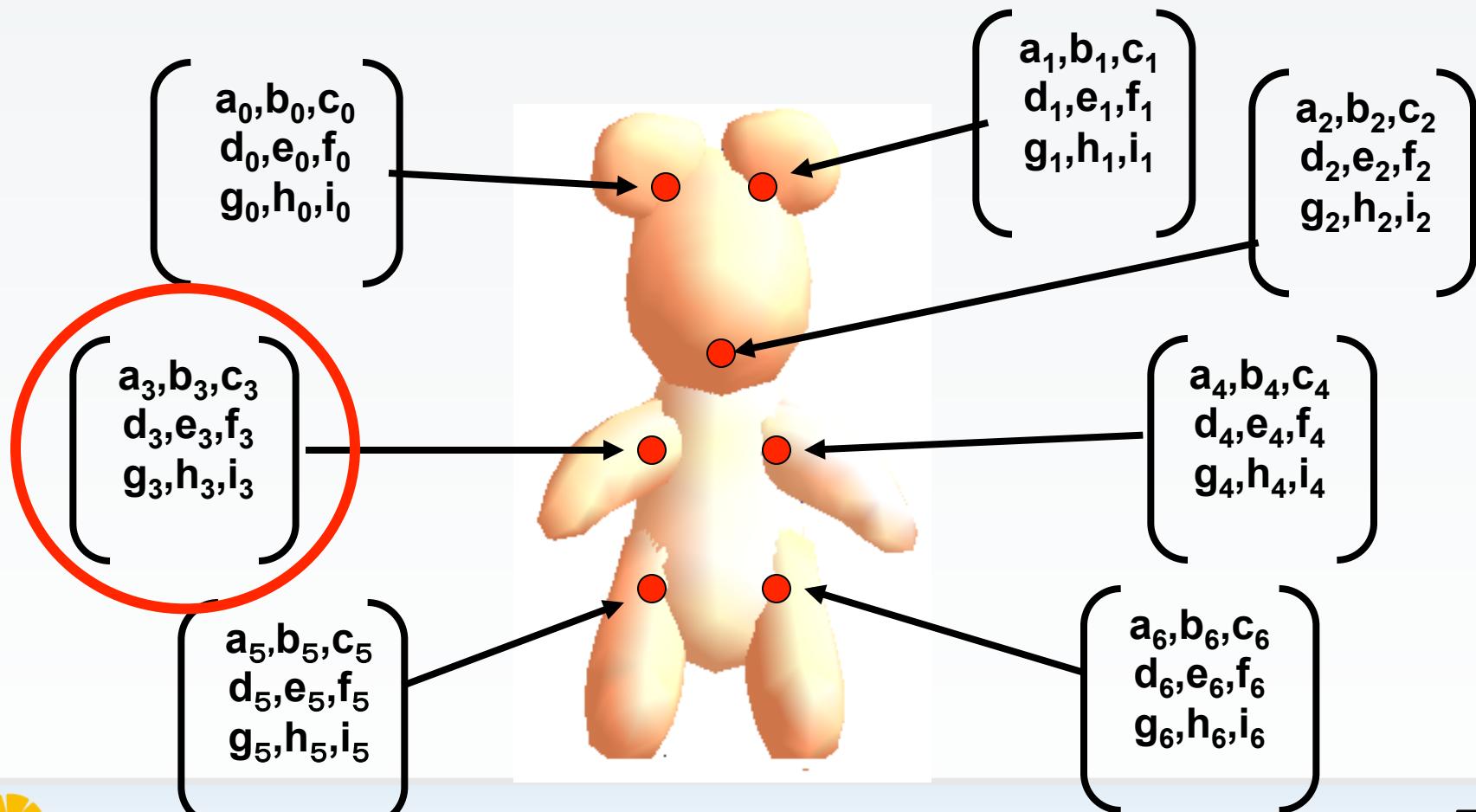
Input: handle coordinates (x,y)

Output: orientation of each joint

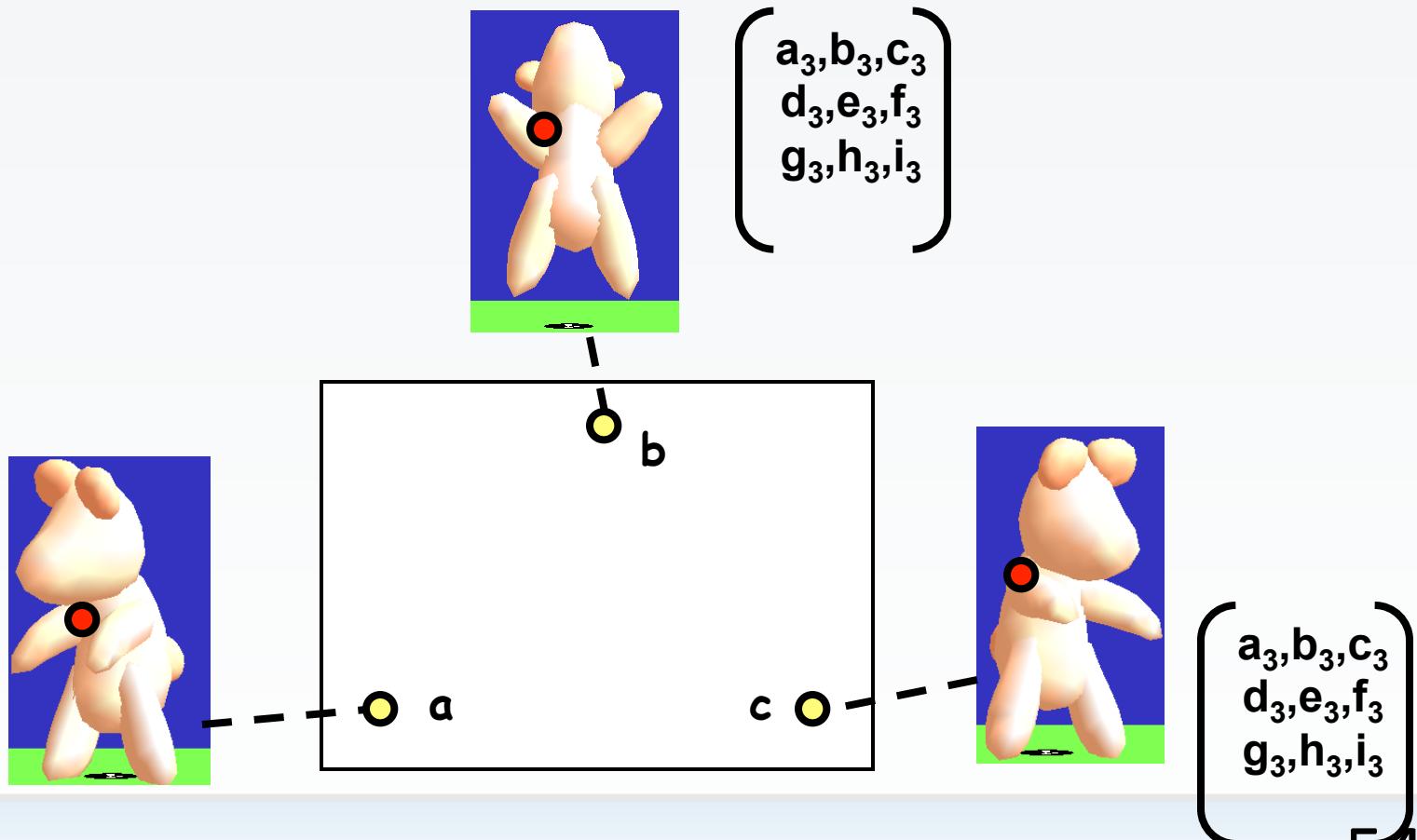
How to represent orientation?

We use **rotation matrix** instead of euler angles or quaternions.

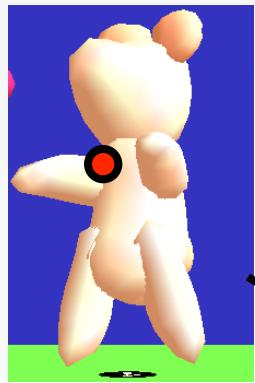
Representing poses with 3x3 rotation matrices



Individually blends each entry using PBFs



Individually blends each entry using PBFs



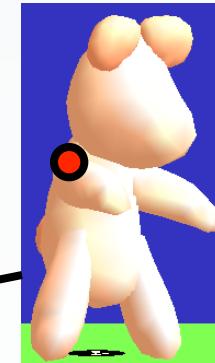
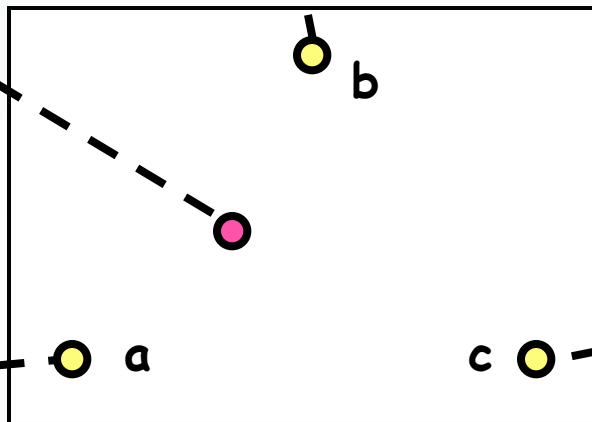
a_3, b_3, c_3
 d_3, e_3, f_3
 g_3, h_3, i_3



a_3, b_3, c_3
 d_3, e_3, f_3
 g_3, h_3, i_3

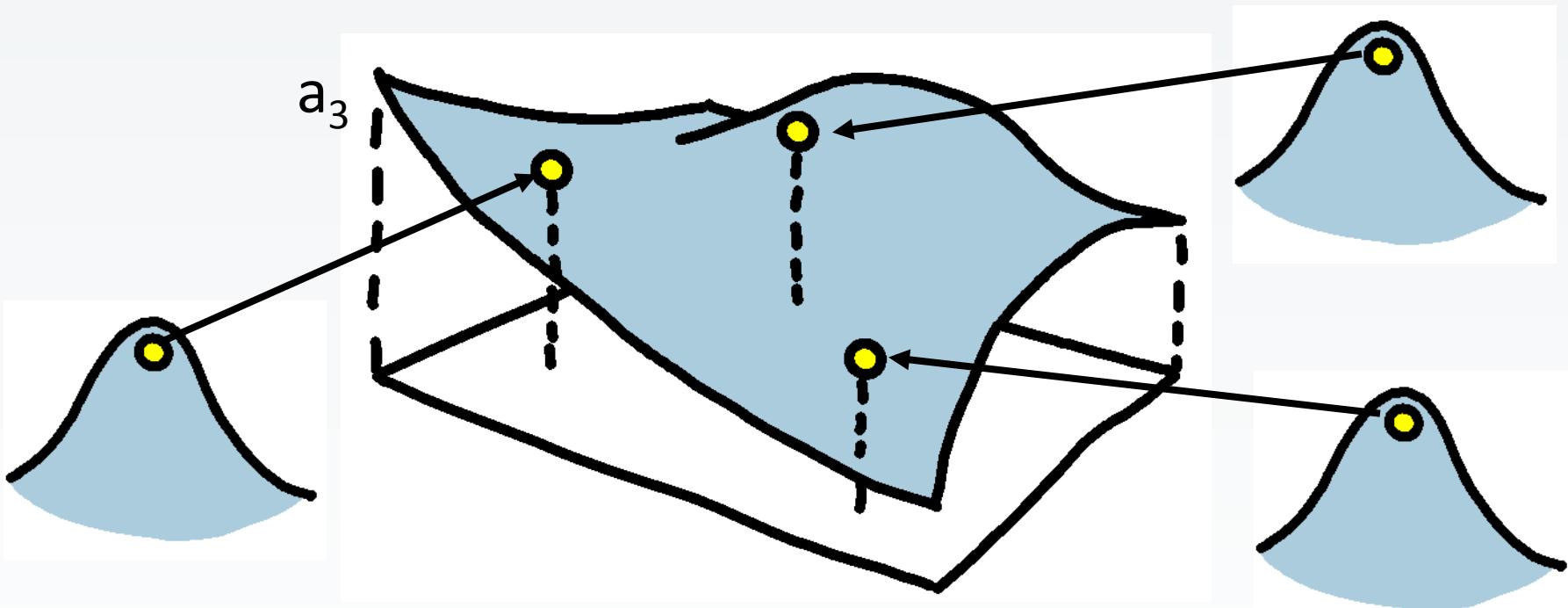


a_3, b_3, c_3
 d_3, e_3, f_3
 g_3, h_3, i_3



a_3, b_3, c_3
 d_3, e_3, f_3
 g_3, h_3, i_3

Scattered data interpolation using radial basis functions

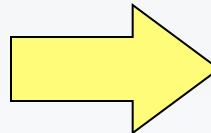


Construct smooth height field
as summation of RBFs.

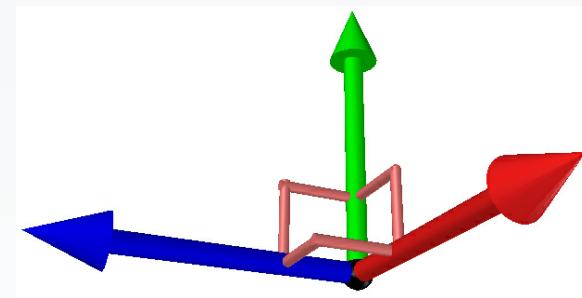
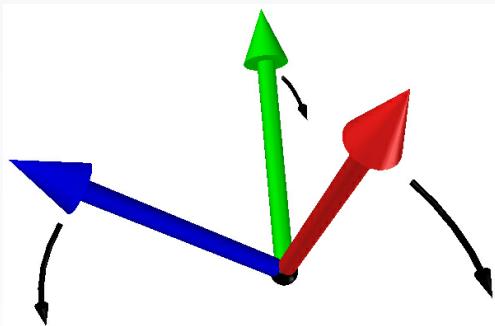
[Turk 02]

Orthonormalization

$$\begin{pmatrix} \mathbf{a}_0, \mathbf{b}_0, \mathbf{c}_0 \\ \mathbf{d}_0, \mathbf{e}_0, \mathbf{f}_0 \\ \mathbf{g}_0, \mathbf{h}_0, \mathbf{i}_0 \end{pmatrix}$$



$$\begin{pmatrix} \mathbf{a}_0, \mathbf{b}_0, \mathbf{c}_0 \\ \mathbf{d}_0, \mathbf{e}_0, \mathbf{f}_0 \\ \mathbf{g}_0, \mathbf{h}_0, \mathbf{i}_0 \end{pmatrix}$$



Blended matrix might not be orthonormal.
So we orthonormalize them.

Summary

Spatial key-framing for character animation.

The user defines key poses in a space.
The system blends nearby poses.

Rotation matrix representation and
Radial basis function interpolation.

To Learn More...

The original paper:

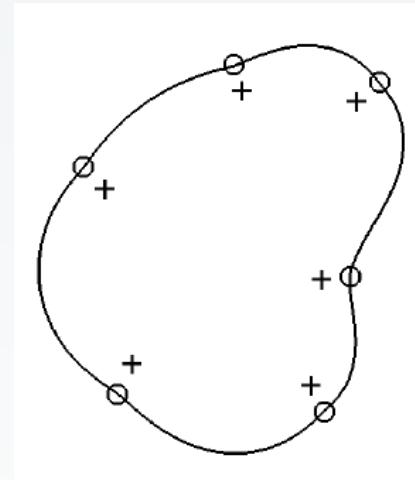
- Igarashi et al. Spatial Keyframing for Performance-driven Animation.
SCA 2005

Interpolation by Radial Basis Function:

- Turk and O'Brien. Modelling with implicit surfaces that interpolate. TOG 2002.

Interpolation of 3D angles (quaternion):

- Shoemake. Animating Rotations with Quaternion Curves. In Computer Graphics. SIGGRAPH 85.



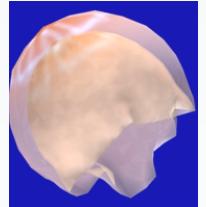
[Turk and O'Brien 2002]

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Deformation and Animation

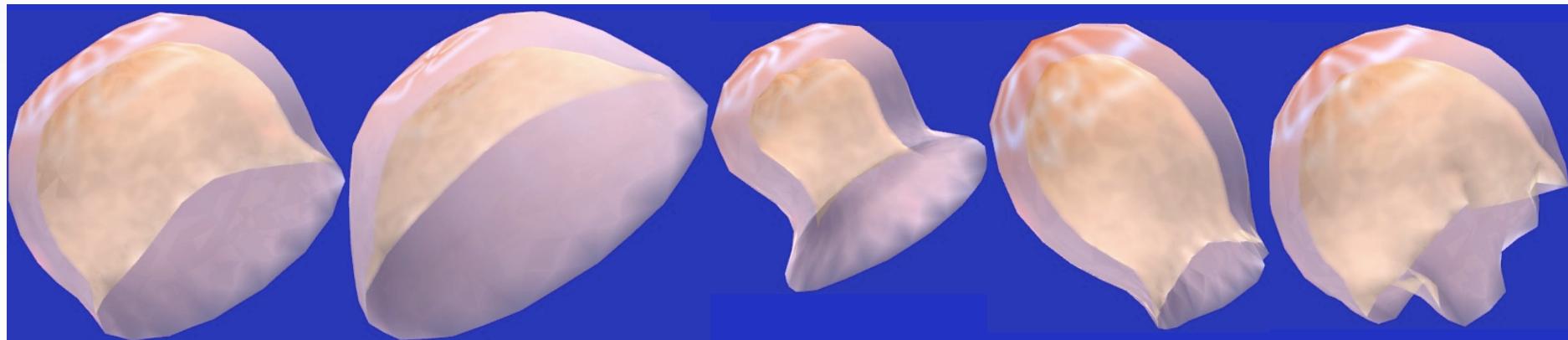
- Clothing Manipulations
- Layer Operations
- Spatial Key Framing
- Procedural Deformation
- Motion Database



ProcDef: Local-to-global Deformation for Skeleton-free Character Animation

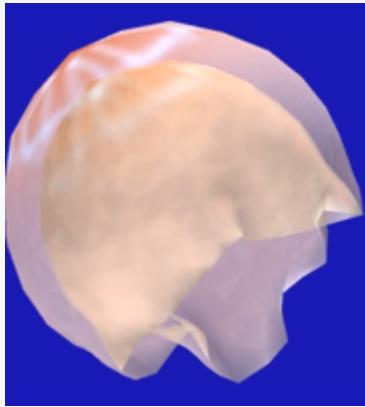
T. Ijiri^{1,2}, K. Takayama¹, H. Yokota², T. Igarashi^{1,3}

1, The Univ. of Tokyo 2, Riken, 3, JST/ERATO



Goal

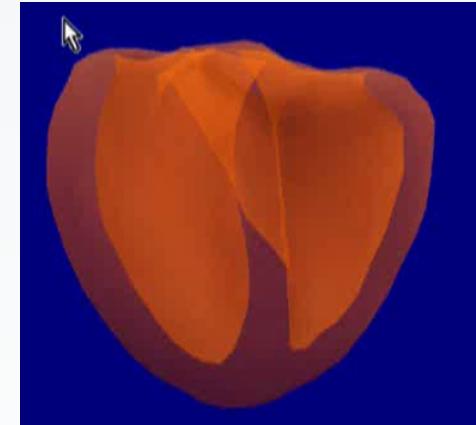
Design of flexible character animation.
Whole body motion + dynamics.



Jelly fish



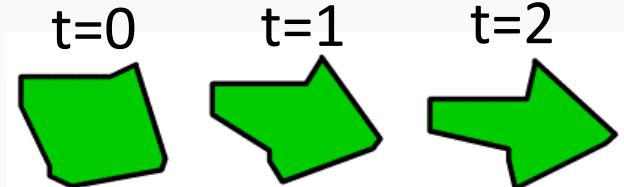
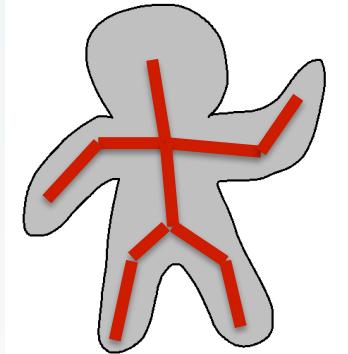
Worm



Intestine

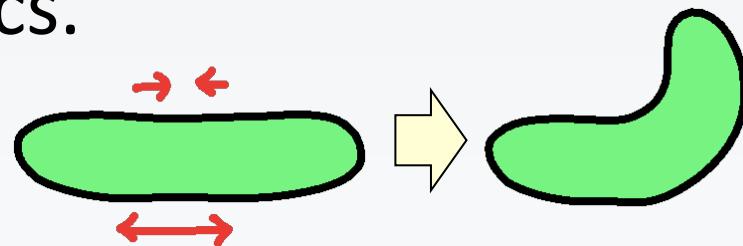
Traditional Methods

- Skeleton-based
 - No obvious skeleton structure
- Keyframe-based
 - Many key poses
 - Cannot calculate dynamics

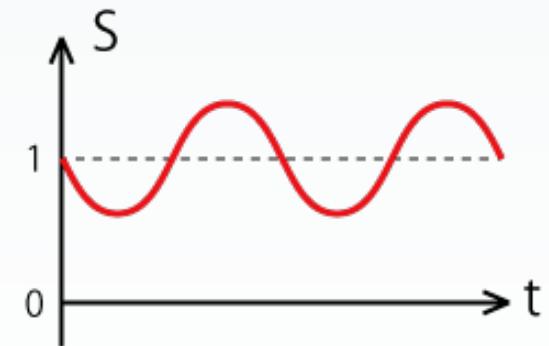


Our Approach

Derive global motion as a result of local deformations + dynamics.



The user designs the patterns of local deformations.



Video

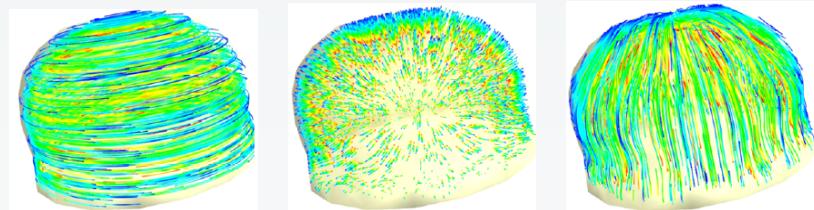
[video](#)



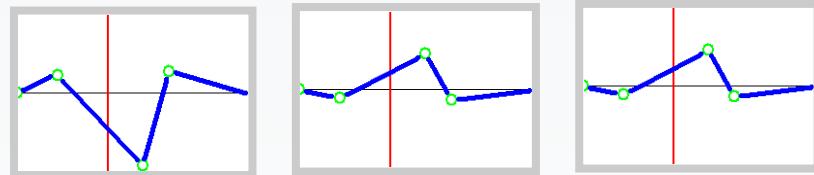
THE UNIVERSITY OF TOKYO

Deformation Design

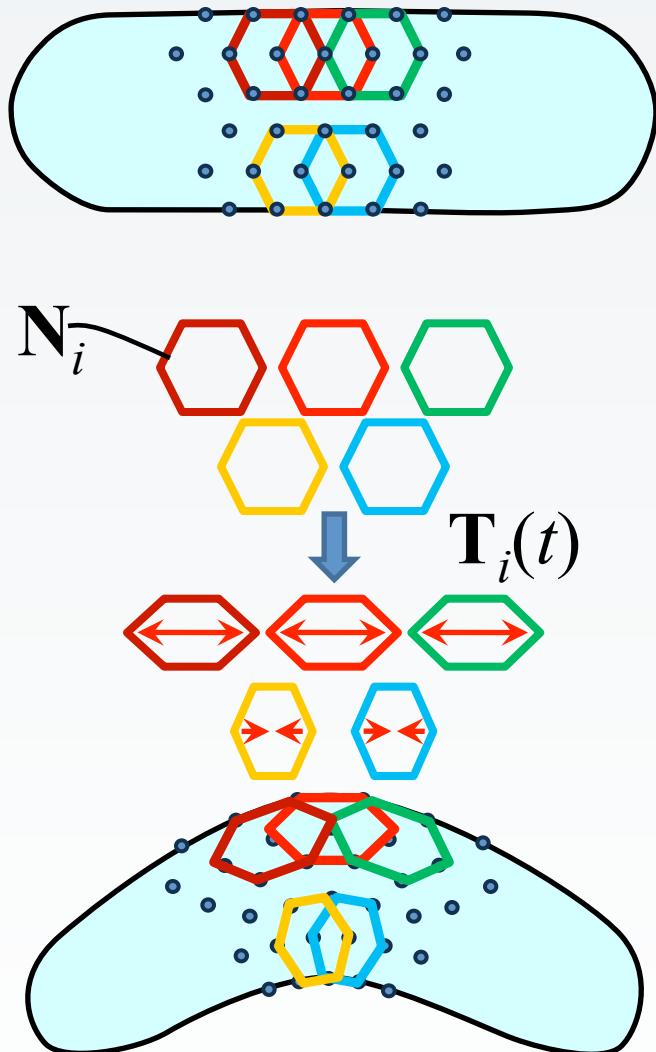
1) Orientation Fields



2) Deformation Charts



Algorithm



Preprocess

Tetrahedral Mesh

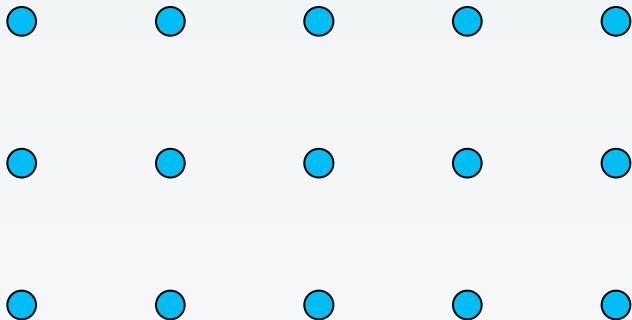
Define local region N_i at each vertex x_i by connecting 1-ring.

Animation process

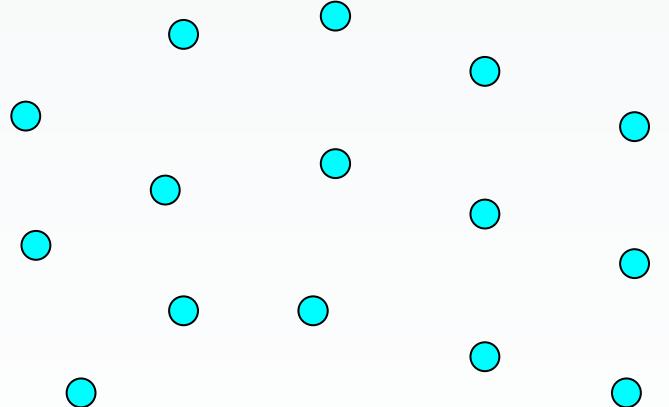
Deform local region N_i by deformation function $T_i(t)$

Deform global shape so as to satisfy deformed local regions.

Dynamics (Shape matching)

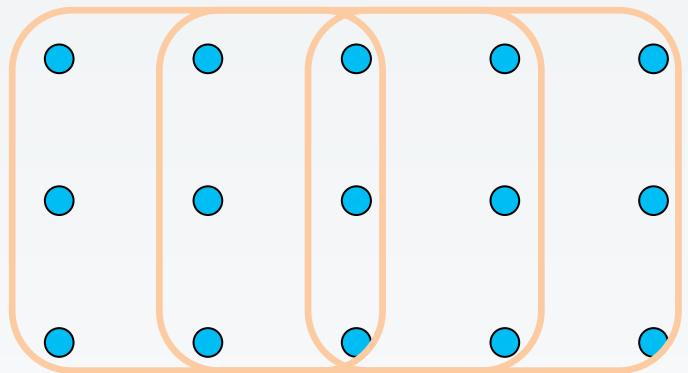


Original mesh
(rest shape)



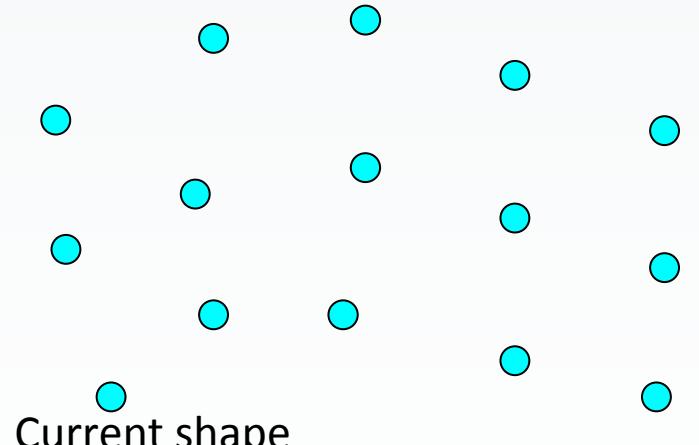
Current shape

Dynamics (Shape matching)



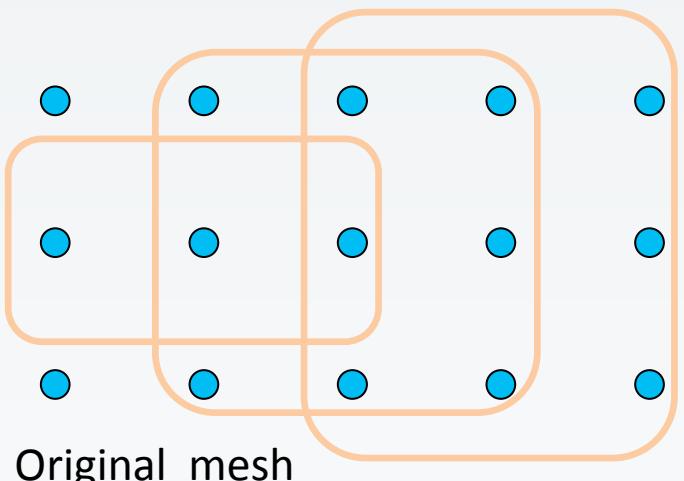
Original mesh
(rest shape)

1) Define local regions.



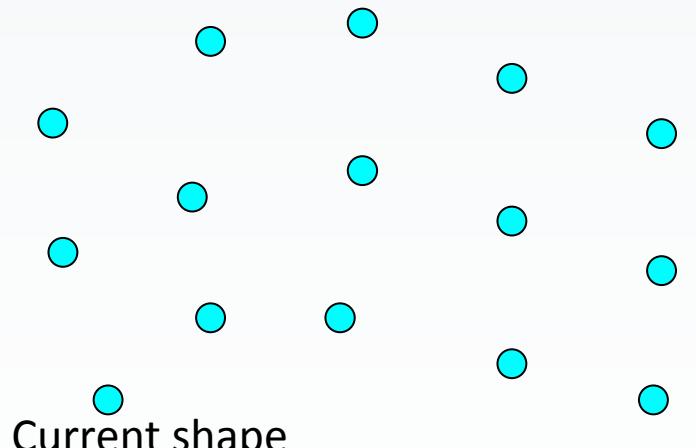
Current shape

Dynamics (Shape matching)



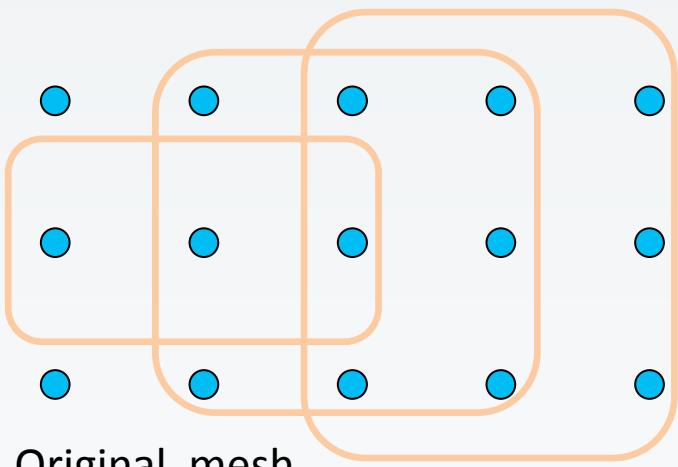
Original mesh
(rest shape)

- 1) Define local regions.
- 2) Deform the local regions independently.



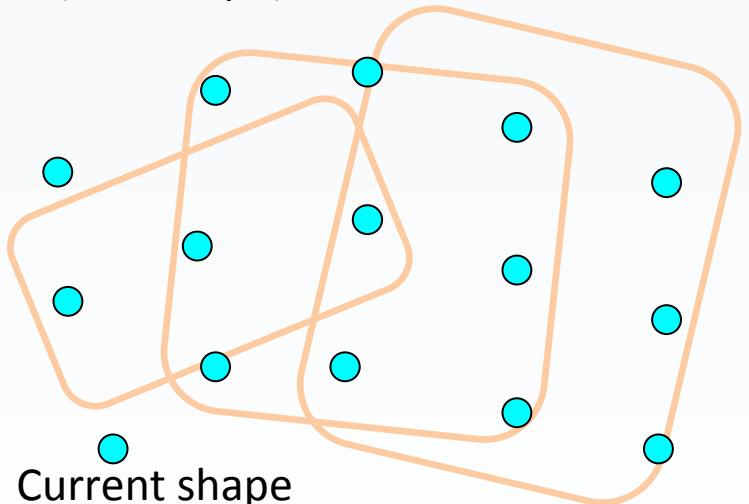
Current shape

Dynamics (Shape matching)



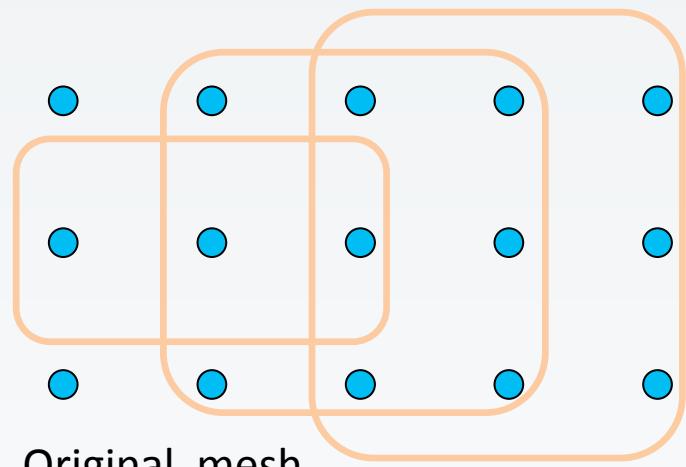
Original mesh
(rest shape)

- 1) Define local regions.
- 2) Deform the local regions independently.
- 3) Find best matching rigid transformation for each region.



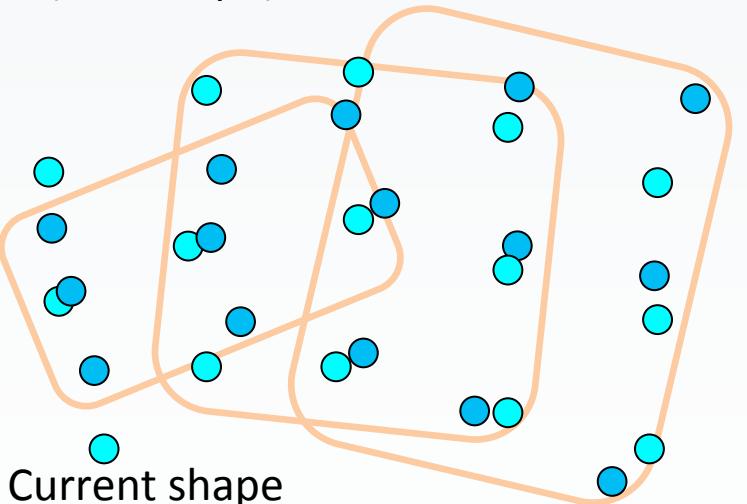
Current shape

Dynamics (Shape matching)



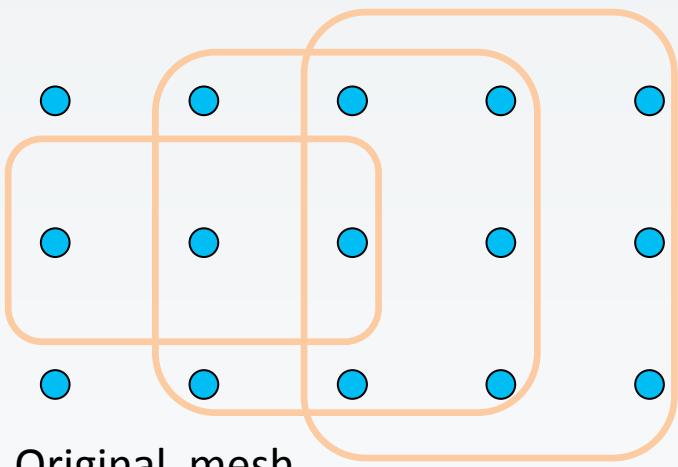
Original mesh
(rest shape)

- 1) Define local regions.
- 2) Deform the local regions independently.
- 3) Find best matching rigid transformation for each region.
- 4) Blend the matching results.

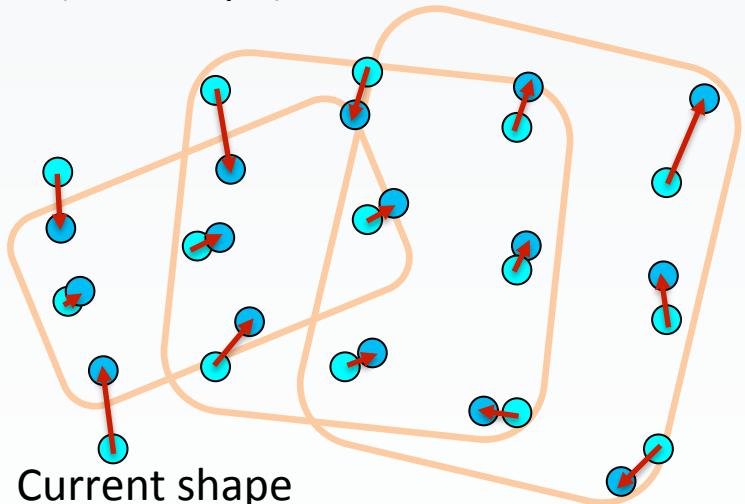


Current shape

Dynamics (Shape matching)



Original mesh
(rest shape)



Current shape

- 1) Define local regions.
- 2) Deform the local regions independently.
- 3) Find best matching rigid transformation for each region.
- 4) Blend the matching results.
- 5) Apply force toward the blend result.

Summary

Animation of deformable characters.

Local to global approach.

Orientation field + deformation pattern

Shape-matching dynamics

To Learn More...

The original paper:

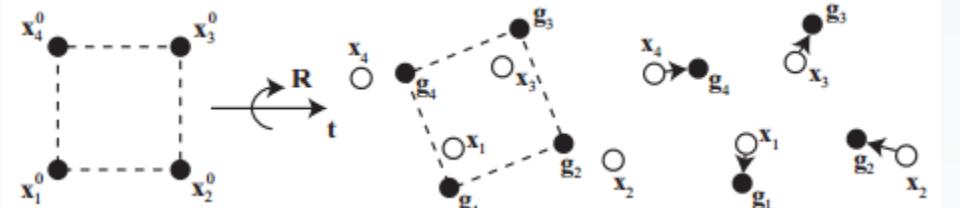
- Ijiri et al. ProcDef: Local-to-global Deformation for Skeleton-free Character Animation. Pacific Graphics 2009.

Design of orientation field:

- Takayama et al. Lapped Solid Textures: Filling a Model with Anisotropic Textures. SIGGRAPH 2008.

Shape matching methods:

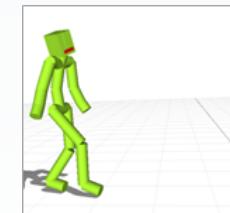
- Müller et al. Meshless deformations based on shape matching. SIGGRAPH 2005.
- Rivers et al. FastLSM: Fast Lattice Shape Matching for Robust Real-Time Deformation. SIGGRAPH 2007.



[Müller et al. 2005]
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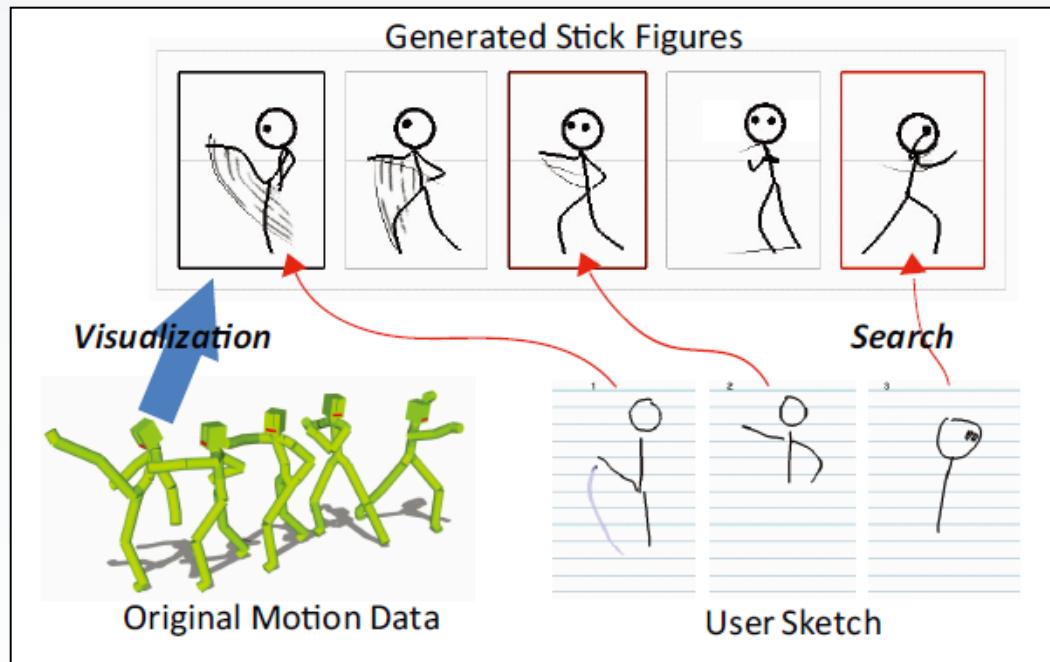
Deformation and Animation

- Clothing Manipulations
- Layer Operations
- Spatial Key Framing
- Procedural Deformation
- Motion Database



Retrieval and Visualization of Human Motion Data via Stick Figures

Myung Geol Choi, Kyung-young Yang, Takeo Igarashi,
Jun Mitani, and Jehee Lee



Motivation

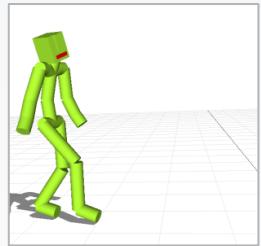


Large motion capture database

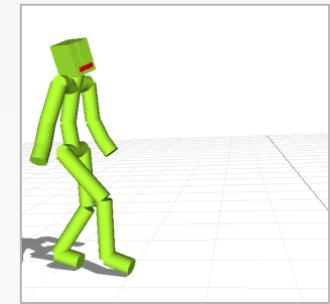
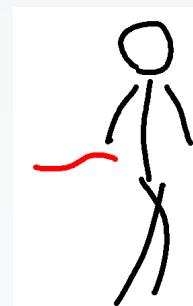


Difficult find a motion.

Our Approach



Comic Visualization



Sketch Search

Video

stick



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Algorithm

1. Visualization
2. Search

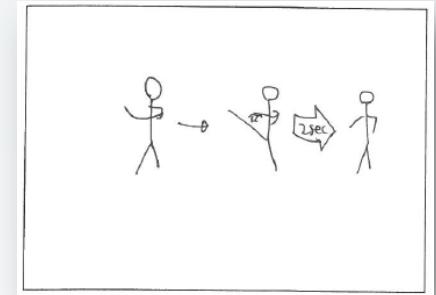
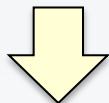
Algorithm

1. Visualization

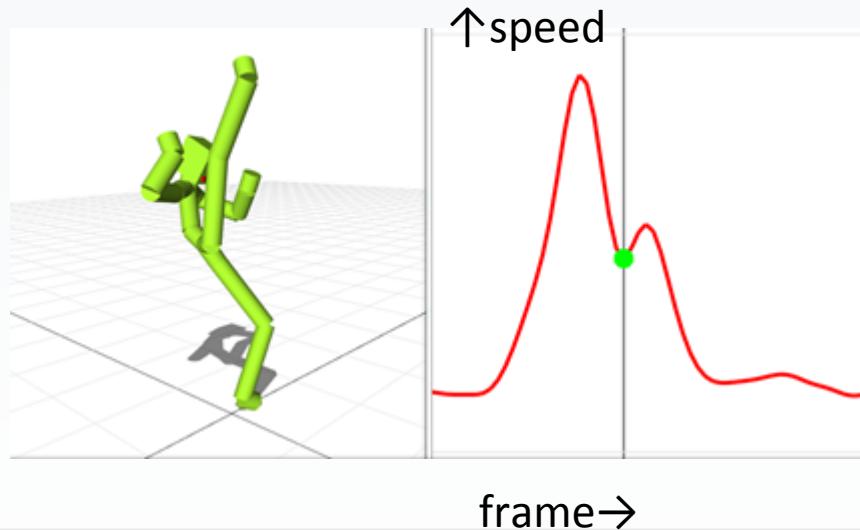
2. Search

Visualization Algorithm

Which pose to use?

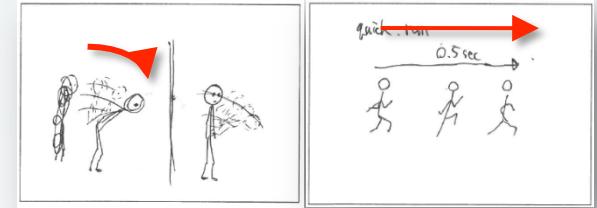
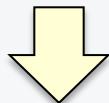


Change in the direction of movement or stop.

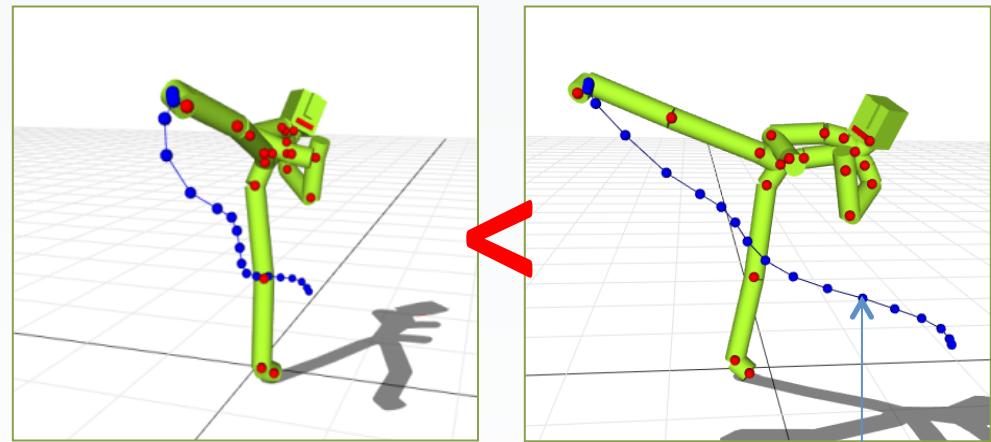


Visualization Algorithm

Which viewing angle to use?



Perpendicular to the movement direction.



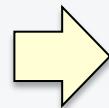
Trajectory
of
the kicking foot.

Algorithm

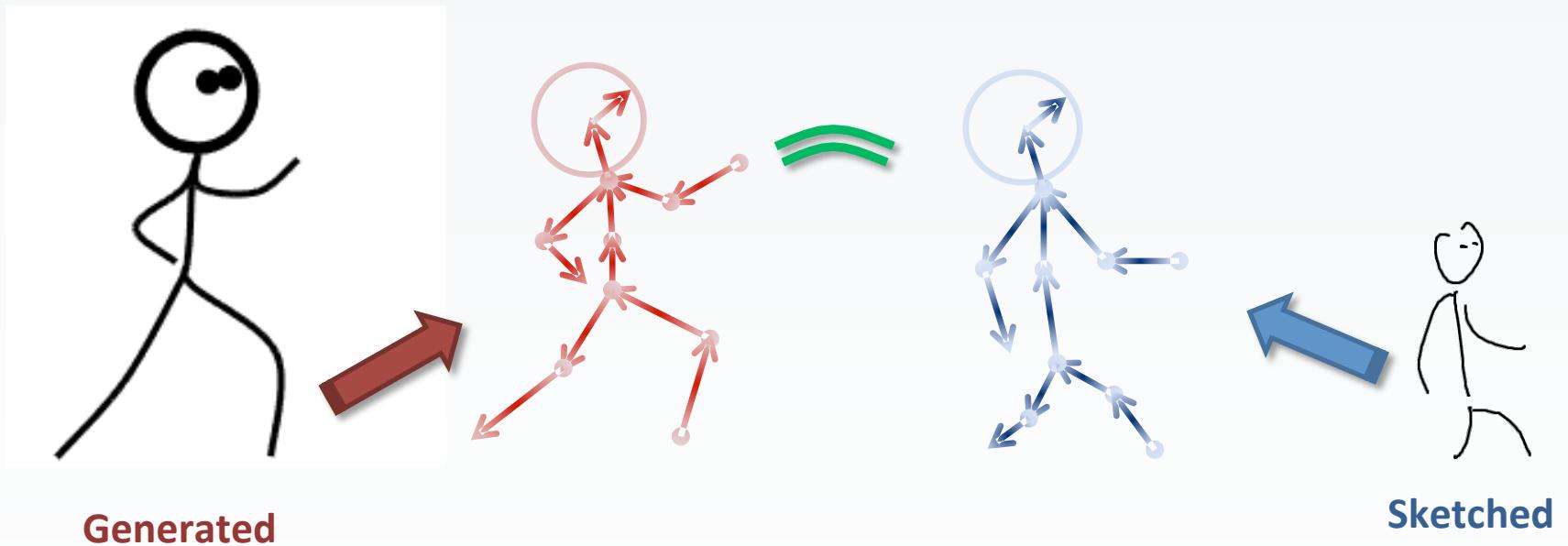
1. Visualization
2. Search

Search Algorithm

Joint locations are not accurate

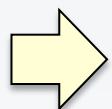


Compare 2D Directions of Bones

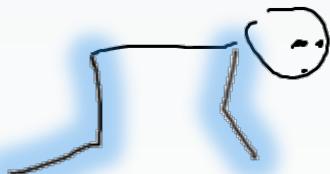


Search Algorithm

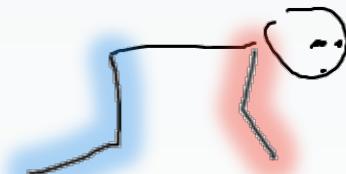
Multiple matching possibilities



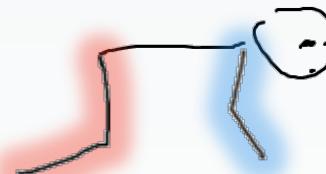
Consider all possibilities



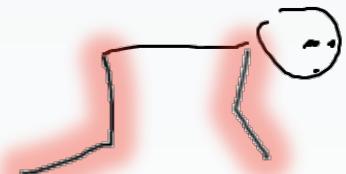
Left Leg



Right Arm



Left Arm



Right Leg Right Arm

Summary

Efficient access to large mocap database.

Comic visualization

Sketch search

Identification of key poses and view directions.

Search by bone direction.

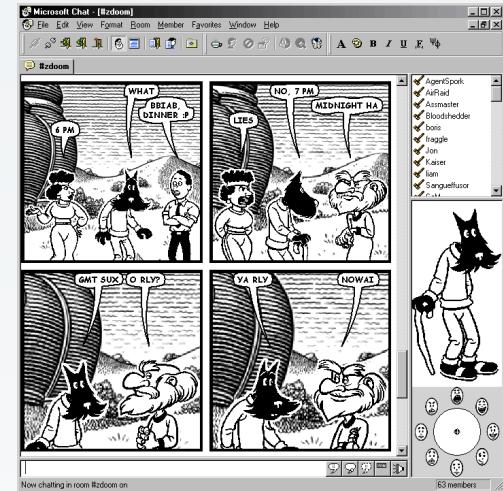
To Learn More...

The original paper:

- Choi et al. Retrieval and Visualization of Human Motion Data via Stick Figures. Pacific Graphics 2012.

Comic-strip visualization:

- Kurlander et al. Comic Chat. SIGGRAPH 1996.



Microsoft Chat version 2.5
Used with permission from Microsoft.

3D model search Engine:

- Funkhouser et al. A search engine for 3D models. TOG 2002.

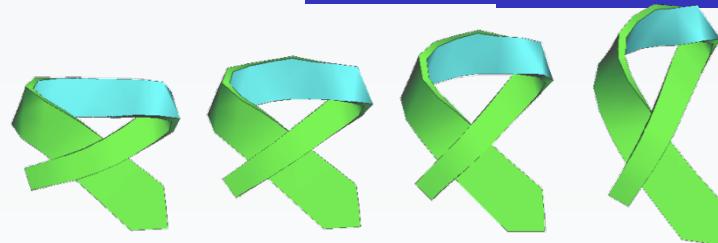
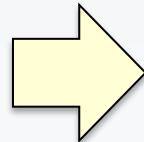
Posing by stick figures:

- Davis et al. A sketching interface for articulated figure animation. SCA 2003.



[Funkhouser et al. 2002]
(Figure obtained from
<http://gfx.cs.princeton.edu/proj/shape/> with permission)

Deformation and Animation



Static 3D shape
“Rigid”

Dynamic 3D shape
“Articulated / Soft”

Deformation and Animation

- Clothing Manipulations
- Layer Operations
- Spatial Key Framing
- Procedural Deformation
- Motion Database

