クレジット:
UTokyo Online Education 学術俯瞰講義 2016 五十嵐健夫

東京大学
THE UNIVERSITY OF TOKYO

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対話的形状モデリング

五十嵐 健夫

東京大学　情報理工学系研究科　教授

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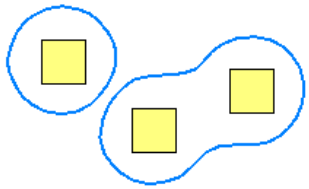
研究分野



User Interface

コンピュータを使いやすくする

Computer Graphics

視覚的な表現を豊かにする

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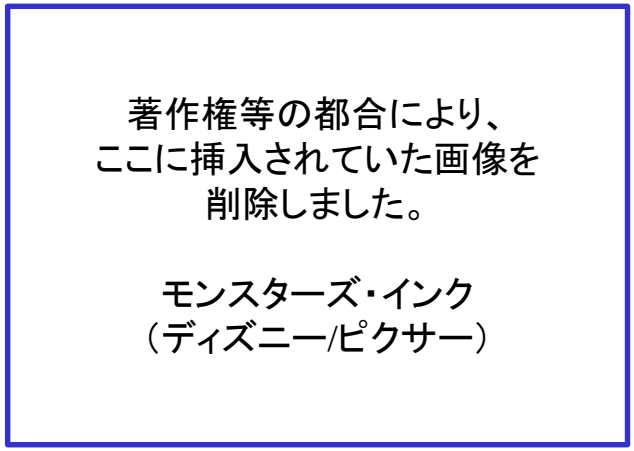
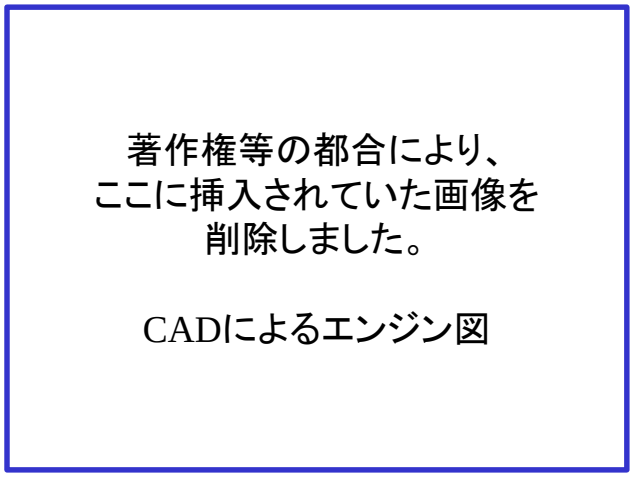
計算機による形状表現

CG



Movie, Game, TV,
Web, Sci., Med.…

CAD



Car, Product,
Building, Clothing …

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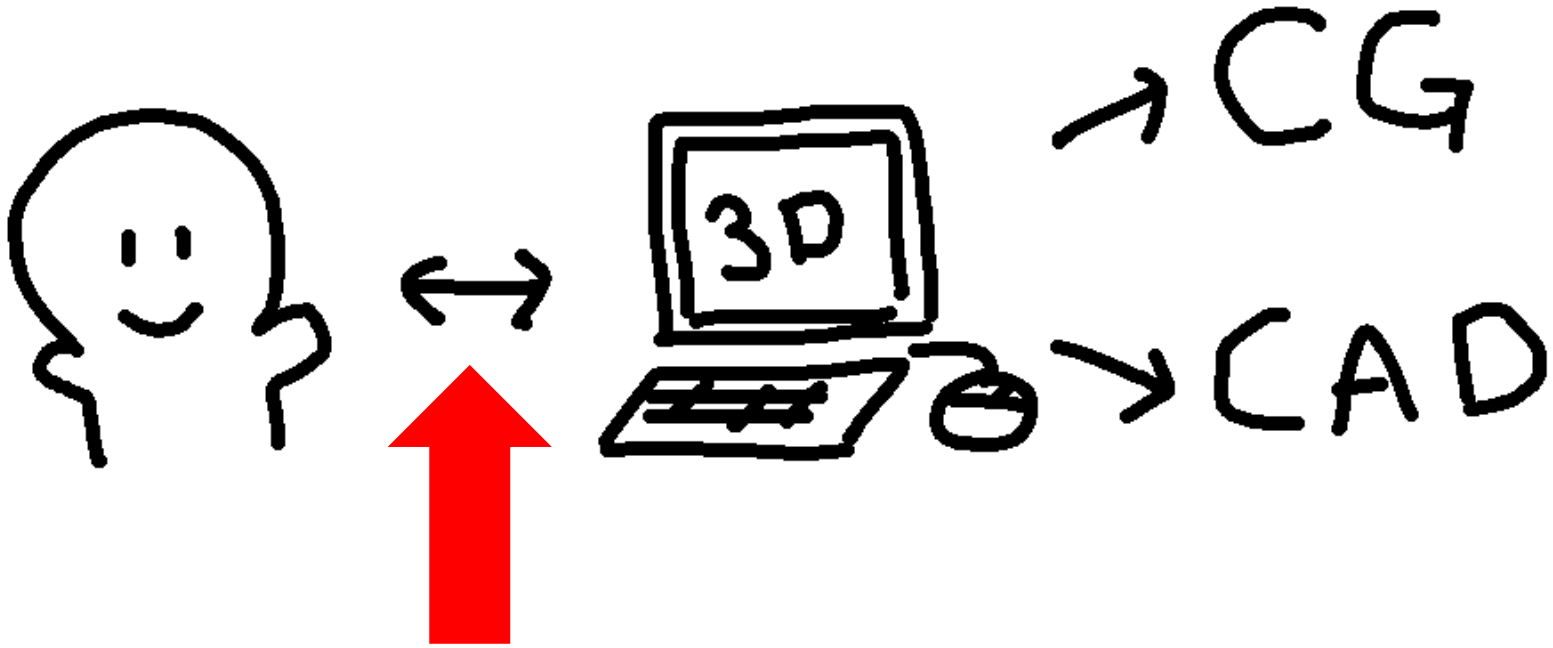
形状モデリング



コンピュータで形状データを作成・編集する。

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Background

Content Creatoin by End-users

TIME
Person of the Year: You | Dec. 25, 2006
http://content.time.com/time/covers/0,16641,20061225,00.html

Neil Gershenfeld, *Fab: The Coming Revolution on Your Desktop--from Personal Computers to Personal Fabrication*, Basic Books, 2007.

Chris Anderson, *Makers: The New Industrial Revolution*, Crown Business, 2014.

Hod Lipson, Melba Kurman, *Fabricated: The New World of 3D Printing*, Wiley, 2013.

Consumer generated contents, Prosumer, Personal fabrication, Maker movement, 3rd Industrial Revolution

Existing Online Platforms

You Tube, shapeways
ニコニコ動画, etc.

Upload, share, and view / print

→ Design is still difficult !

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Research Goal

"Help people **design** things by themselves"

Graphics (3D, animation)

Physical objects (clothing, furniture)

Focusing on "interaction" (~~automation~~)

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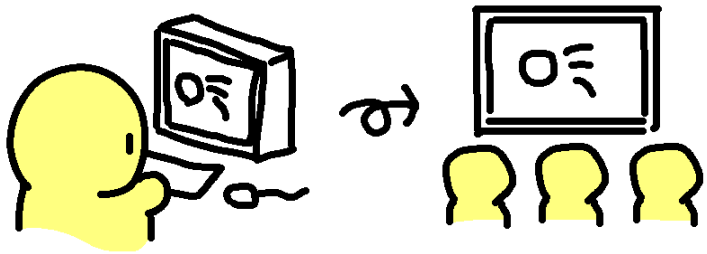
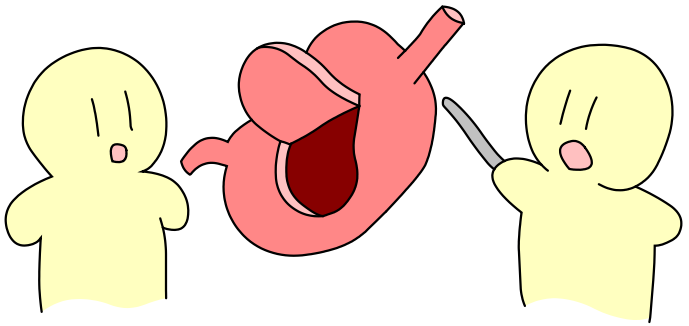
Goal

Dedicated construction by experts
for later presentation



Instant construction by novices
for live communication



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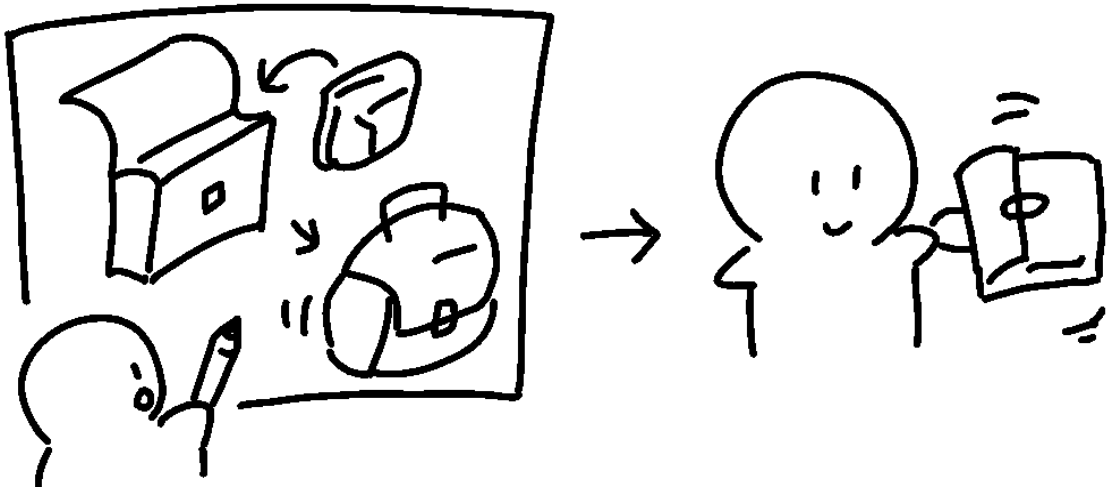
Goal

Farewell to Mass Production and Consumption

"Design Your Own Artifacts by Yourself"



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概要

1）２次元グラフィクス

2）３次元グラフィクス

3）形状変形・アニメーション

4）CAD（ファブリケーション）

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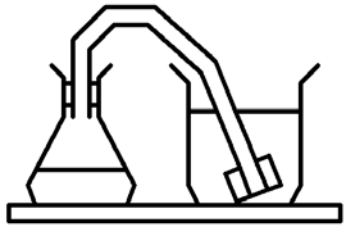
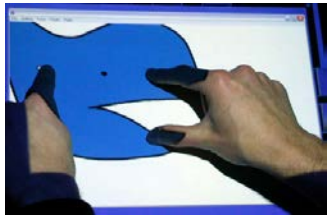
2D Drawings and Animations

- Diagram Beautification
- Shape Manipulation
- Dynamic Illustrations





Sketch-based Dynamic Illustration of Fluid Systems“ ACM Transactions on Graphics, Volume 30, Issue 6, Proceedings of SIGGRAPH Asia 2011, 12-15 Dec, 2011.

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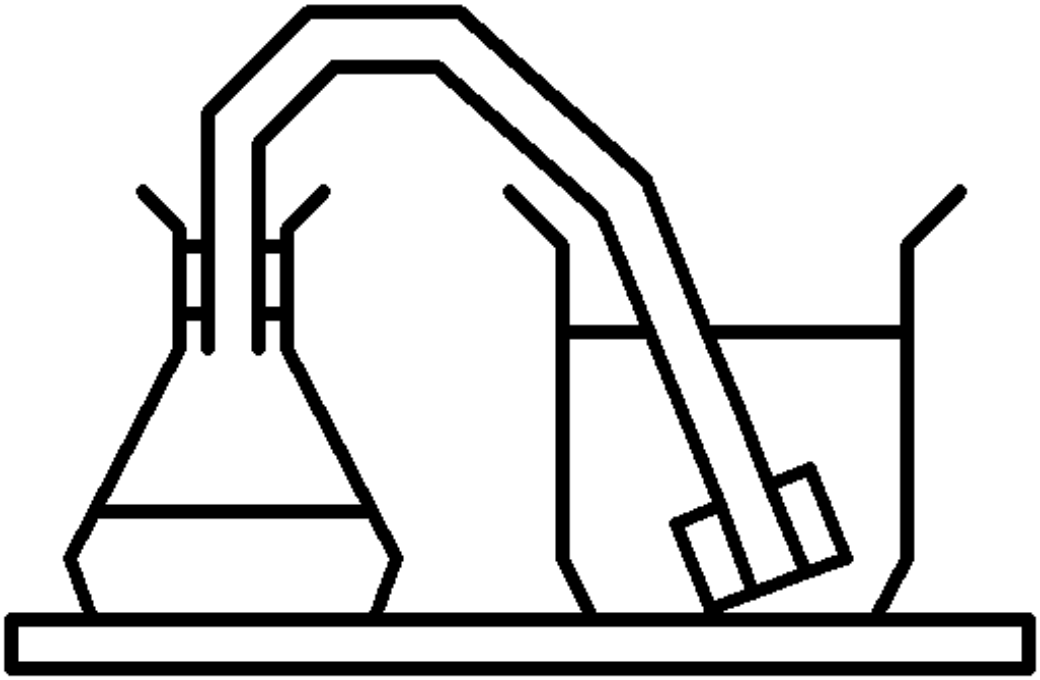
Problem



How do you draw this?

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Demo

pegasus

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Algorithm

1. Beautification
2. Prediction

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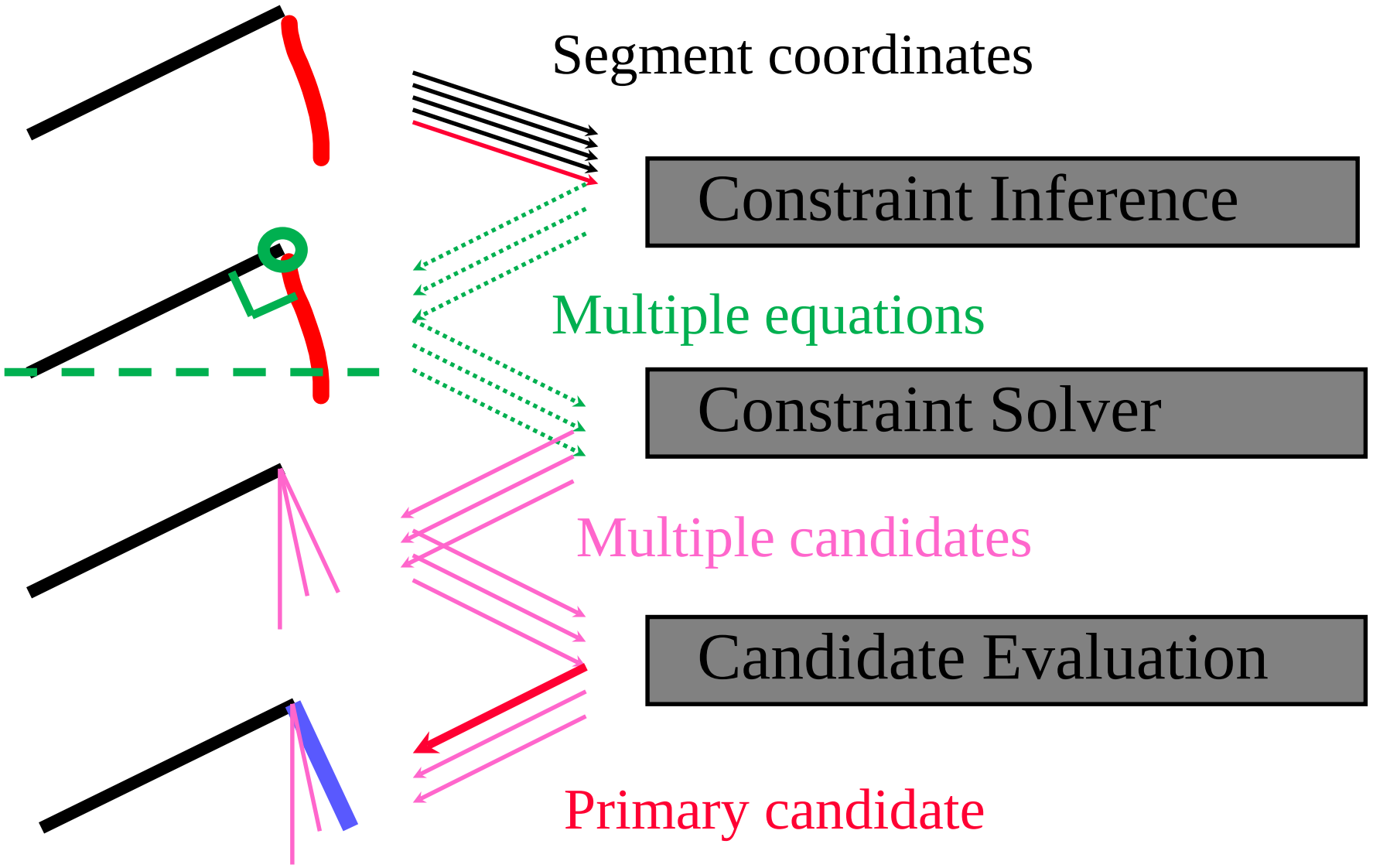
1. Beautification Algorithm



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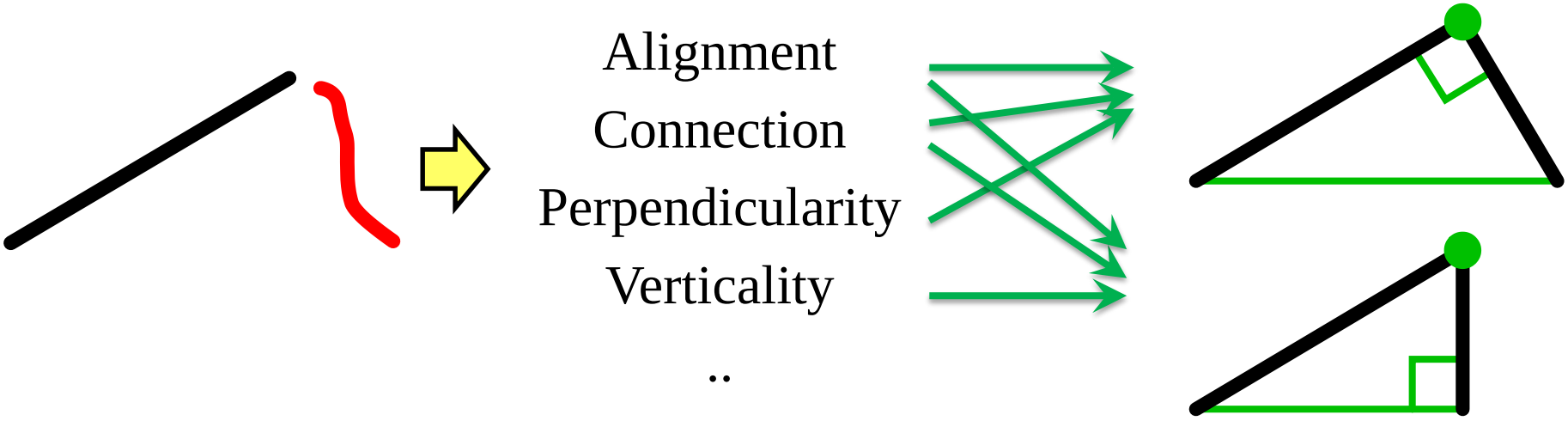
Constraint Solver



Find valid combination of constraints.

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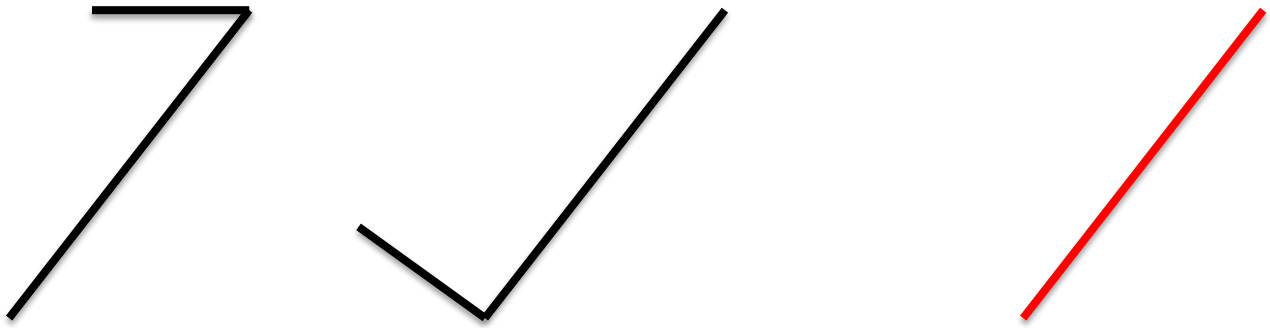
2. Prediction Algorithm



Existing segments

New segment

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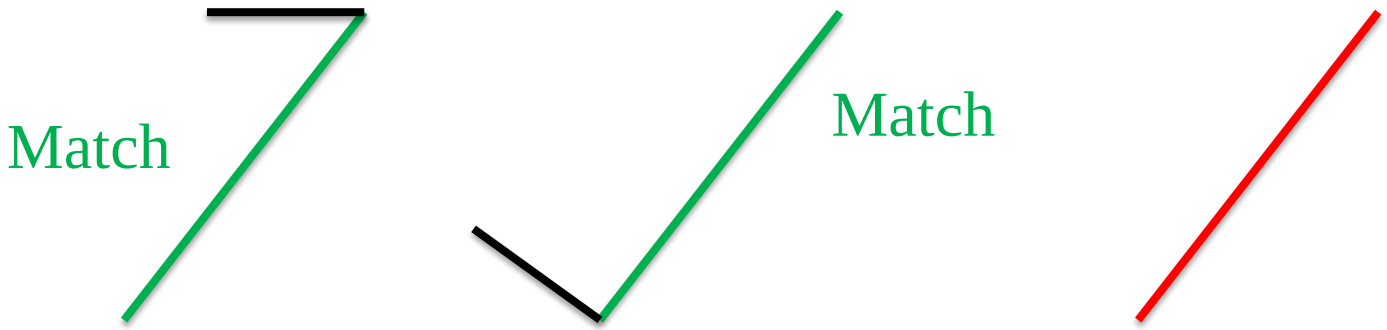
2. Prediction Algorithm



Existing segments

New segment

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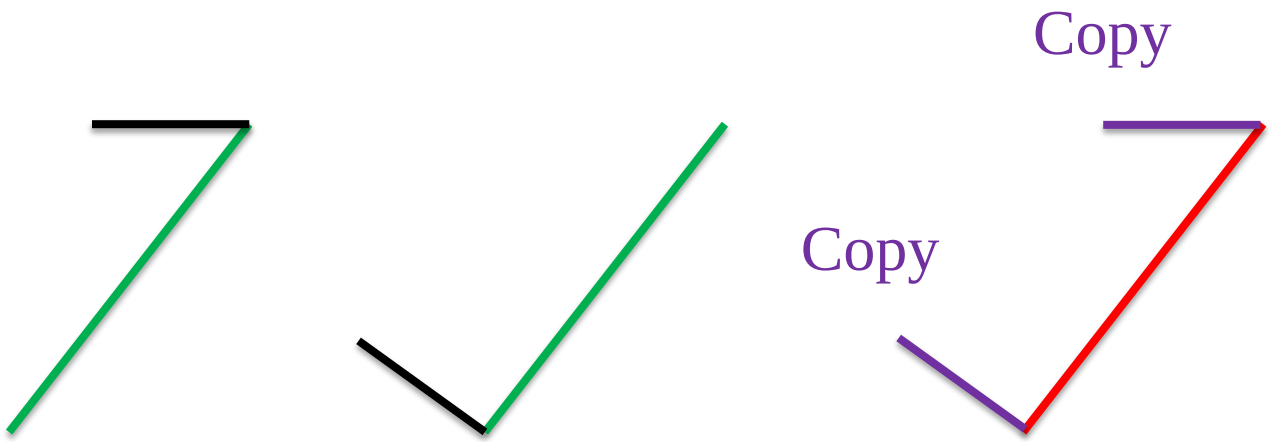
2. Prediction Algorithm

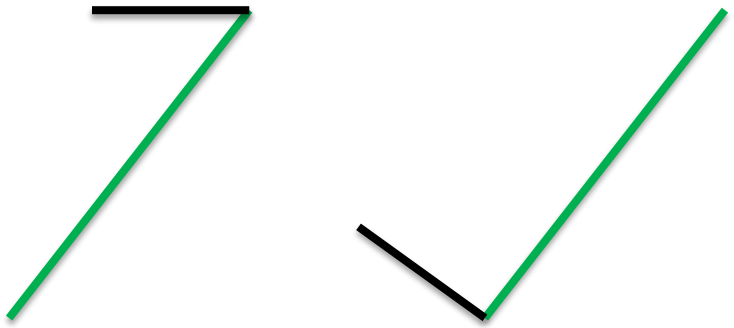


Existing segments

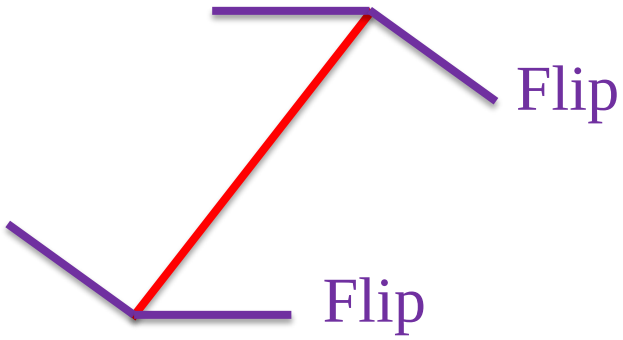
New segment

20160623

2. Prediction Algorithm



Existing segments



New segment

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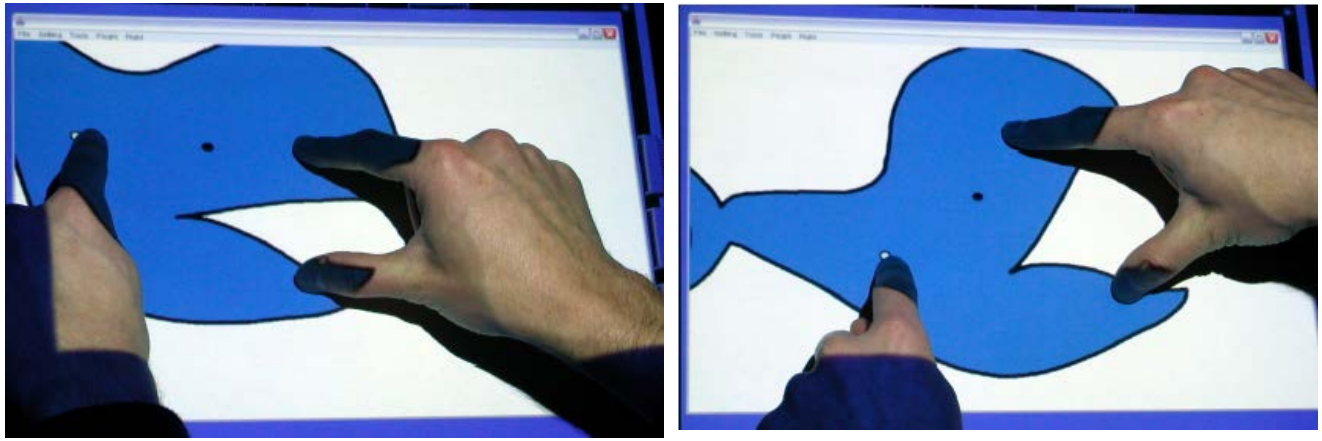
マウスや指で
絵を動かすシステム



Takeo Igarashi, Tomer Moscovich, John F. Hughes

The University of Tokyo / Brown University

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やりたいこと

両手でぬいぐるみをいじるように
コンピュータの中の絵を動かしたい。

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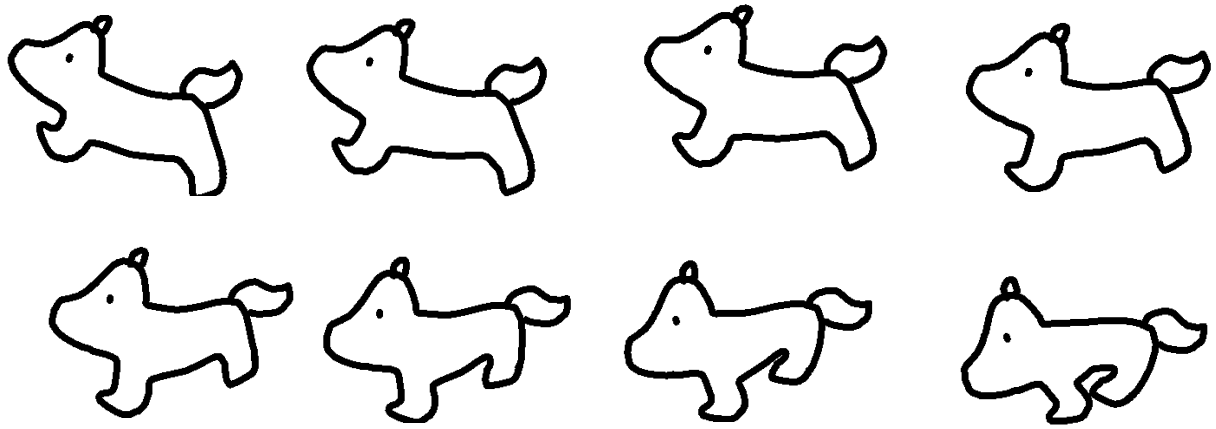
いままでのアニメーションの作り方



絵を一枚ずつすべて手で描く

とっても大変！

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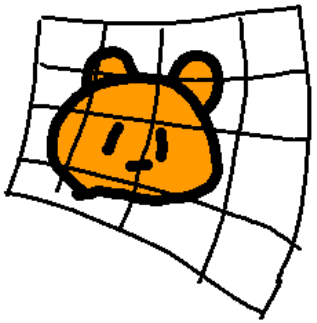
Space-Warp



Deform space, not object.
Different from reality…

Physics (mass-spring model)

Slow to converge…
Unstable, need tuning…

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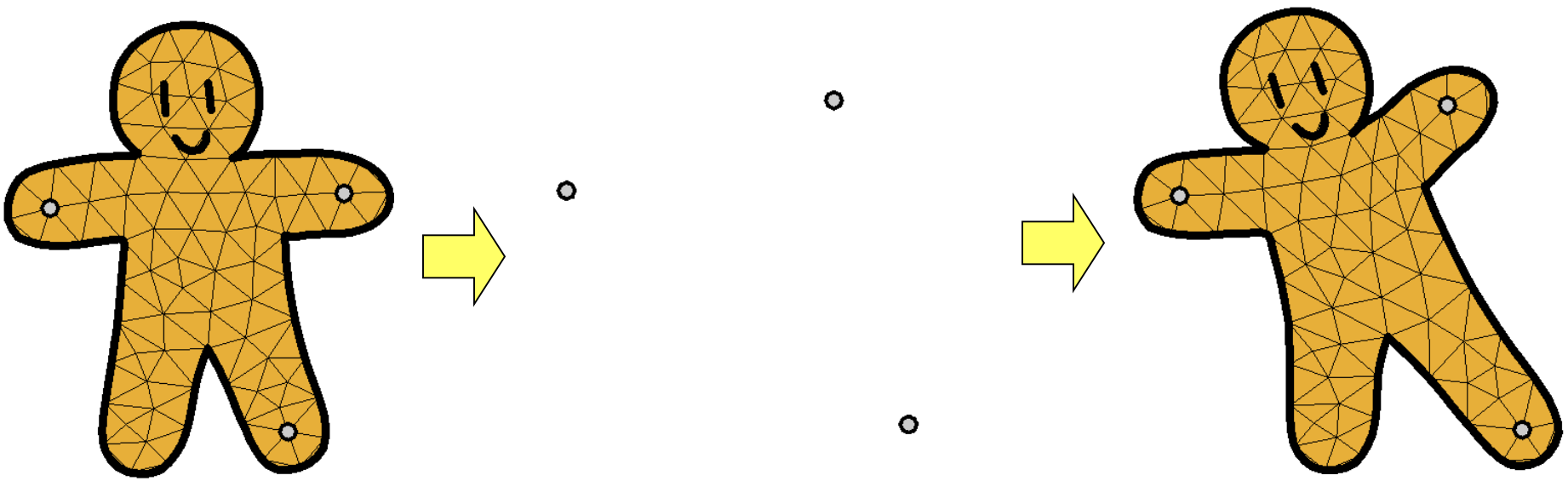
Algorithm



Rest shape Handles Output

Minimize shape distortion, satisfying constraints.
Closed-from solution, not iterative.

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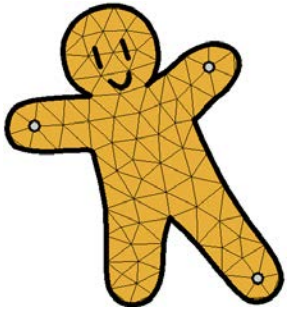
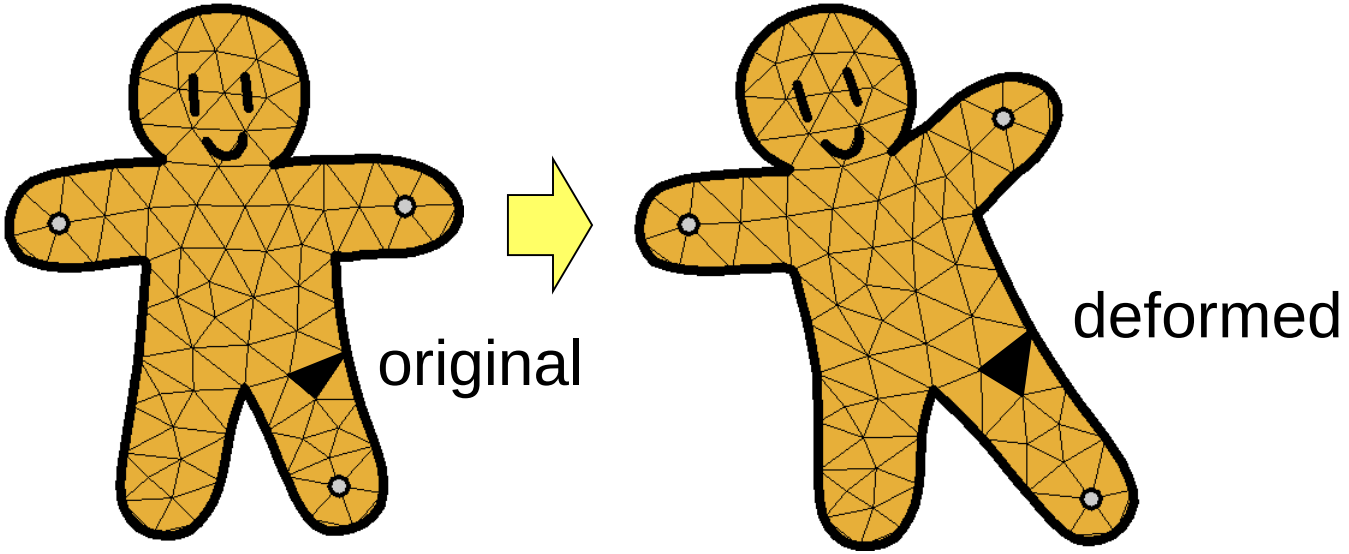
Input: coordinates of handles (**q**)

Output: coordinates of mesh vertices (**u**)



Minimize: distortion of triangles



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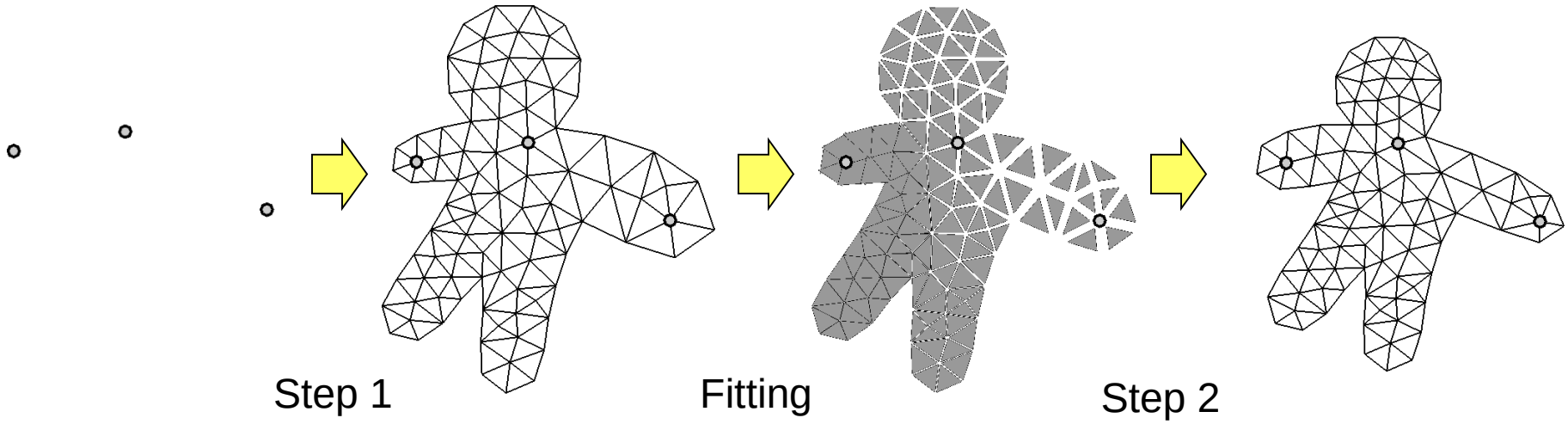
Two-Step Algorithm



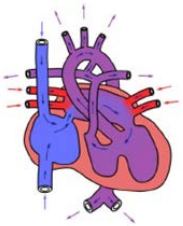
Step 1: Obtain intermediate result by using E_1, allowing scaling.

Fitting: Fit correct-sized individual triangle to the result.

Step 2: Stitch fitted triangles by using E_2.

2D Drawings and Animations

- Diagram Beautification
- Pen-and-ink Textures
- Shape Manipulation
- Dynamic Illustrations

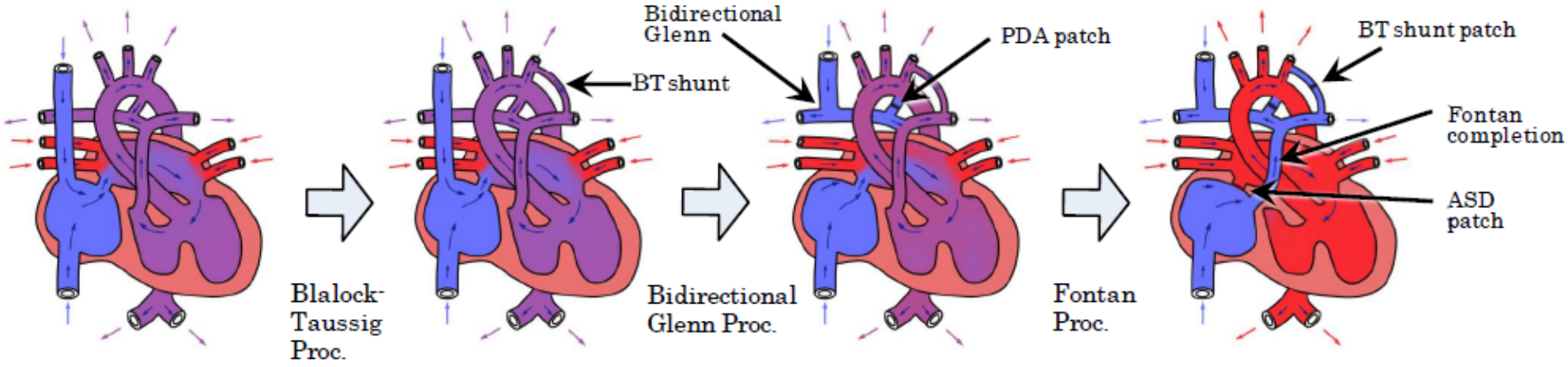


Sketch-based Dynamic Illustration of Fluid Systems“ ACM Transactions on Graphics, Volume 30, Issue 6, Proceedings of SIGGRAPH Asia 2011, 12-15 Dec, 2011.

SIGGRAPH Asia 2011

Sketch-based Dynamic Illustration of Fluid Systems

B. Zhu, M. Iwata, R. Haraguchi, T. Ashihara,
N. Umetani, T. Igarashi, K. Nakazawa



Sketch-based Dynamic Illustration of Fluid Systems“ ACM Transactions on Graphics, Volume 30, Issue 6, Proceedings of SIGGRAPH Asia 2011, 12-15 Dec, 2011. , Figure 1

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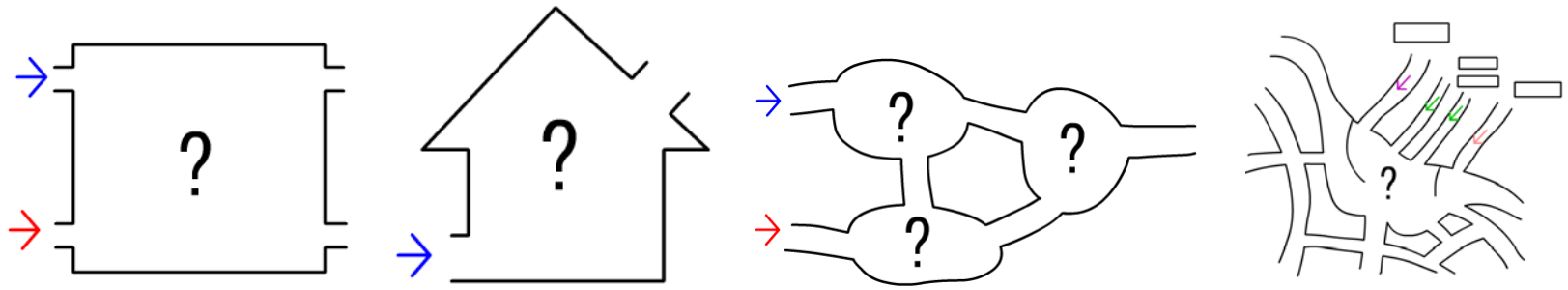
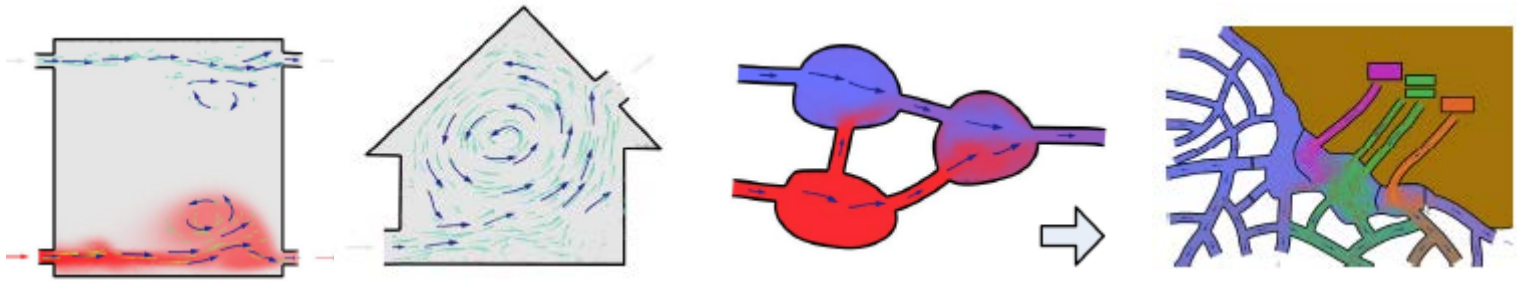
空気や液体の流れを描くのは大変.



計算機が自動的に計算して提示.



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Video

fluid

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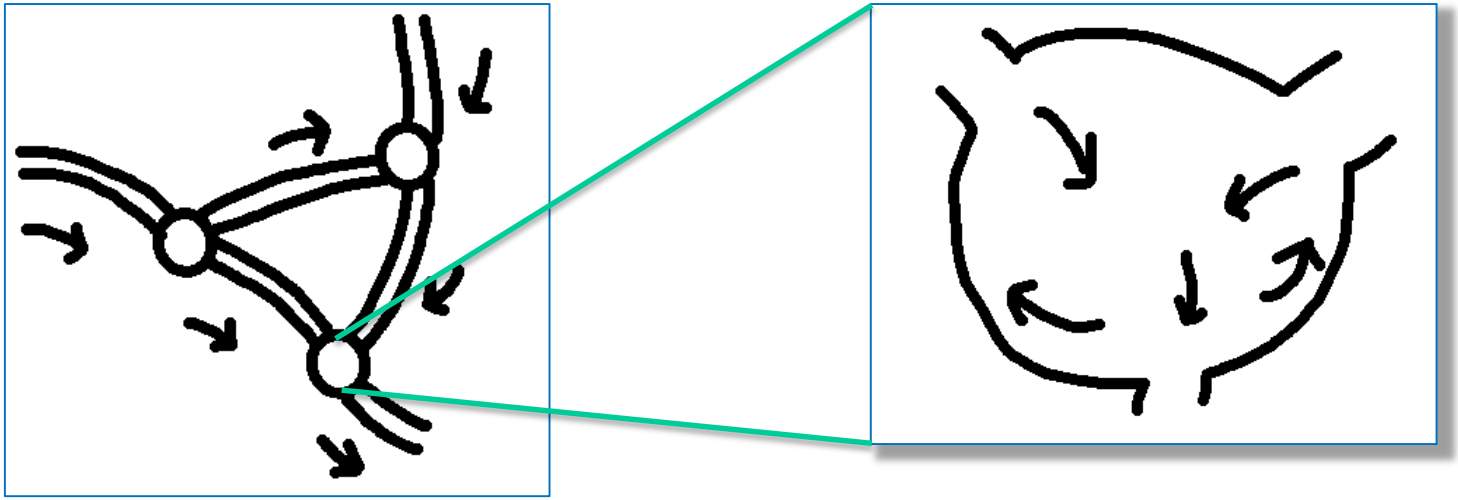
Hybrid Fluid Simulation

Global network

Local region



Hydraulics

Hydrodynamics

Node Inflow → Pipe Flow
Node Pressure → Details within regions

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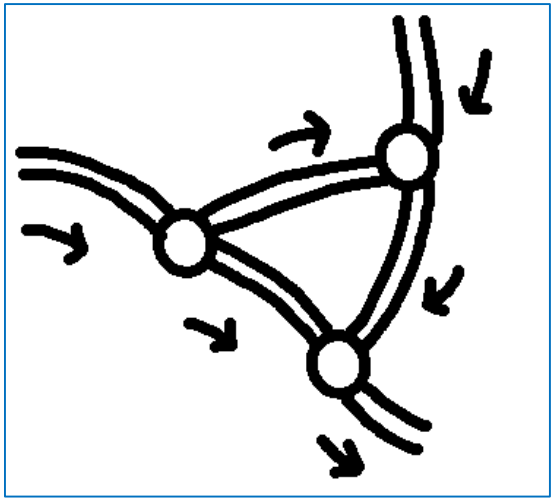
Global network



Hydraulics

Node Inflow → Pipe flow

$$Q_n = -\mathbf{M} Q_e$$

Pipe flow → Pipe pressure drop

$$Q_e = \mathbf{D}_e P_e$$

Pipe pressure drop → Node pressure

$$P_e = -\mathbf{M}^T P_n$$

Solve a global linear system.

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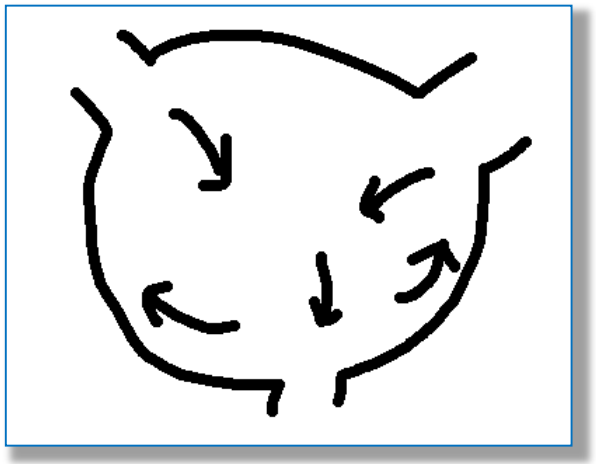
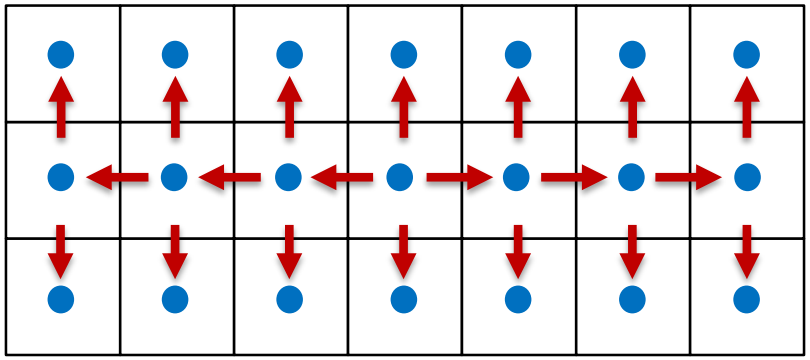
Local region





Velocity ↑ Pressure •

Hydrodynamics

$$\frac{\partial \mathbf{u}}{\partial t} + \mathbf{u} \cdot \nabla \mathbf{u} = -\frac{1}{\rho} \nabla p + \mathbf{g} + \nu \nabla \cdot \nabla \mathbf{u},$$

$$\nabla \cdot \mathbf{u} = 0,$$

(Navier-Stokes Equation)

Solve this on grid cells inside each region.

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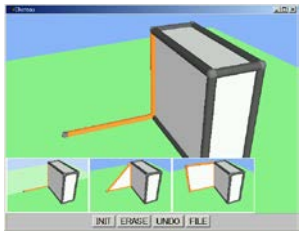
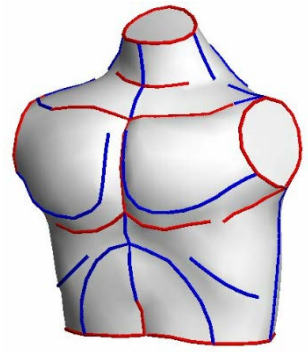
3D Modeling

- Suggestive Interface
- Sketch-based Modeling





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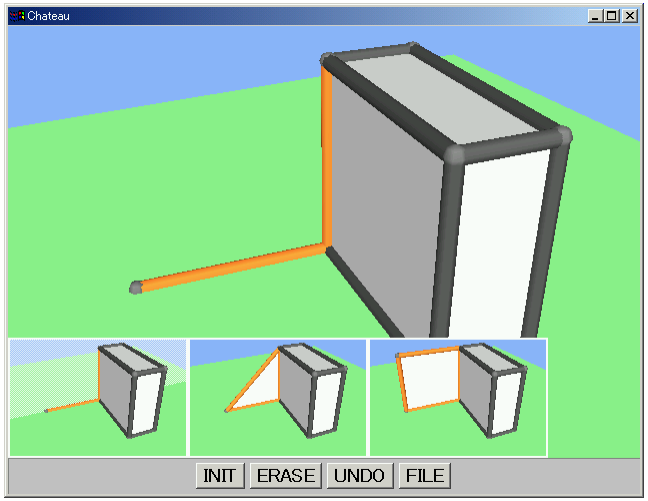
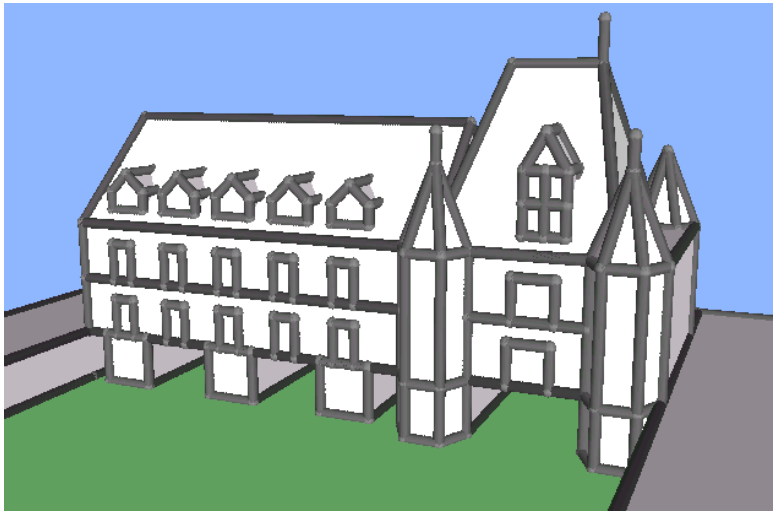
Chateau: a suggestive interface for 3D modeling

Takeo Igarashi, John F. Hughes





User interface using hints and suggestions

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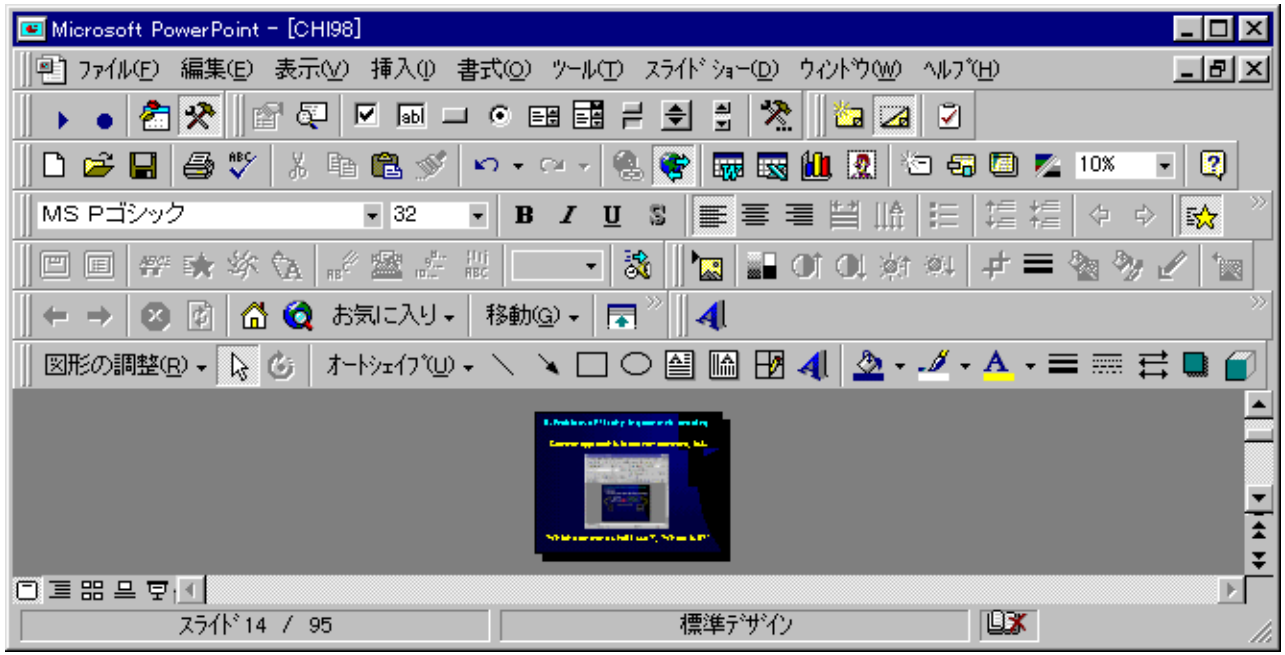
Motivation



So many commands in nested menus!

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Demo

Chateau

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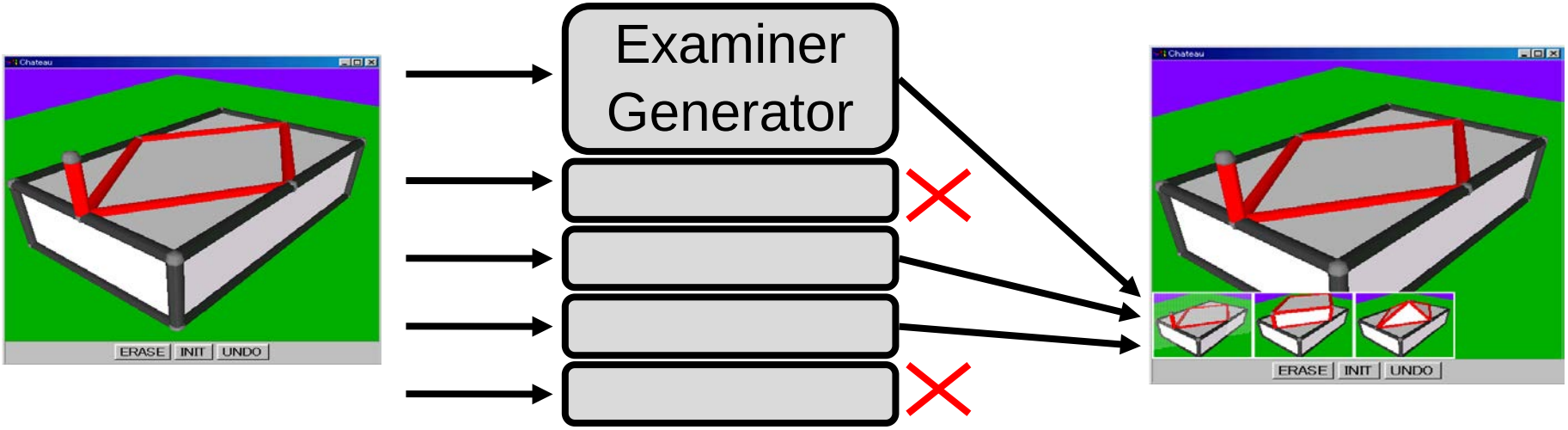
Implementation



Scene

Suggestion engines

Suggestions

Each engine observes the scene and generates a suggestion when the scene matches its input pattern.

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Future Work

Other applications (e.g. PowerPoint)

Roughly aligned

Suggest

Align left

Align center

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SIGGRAPH 99
Impact paper

手書きスケッチによる３次元モデリング Ｔｅｄｄｙ

Takeo Igarashi

Satoshi Matsuoka

Hidehiko Tanaka

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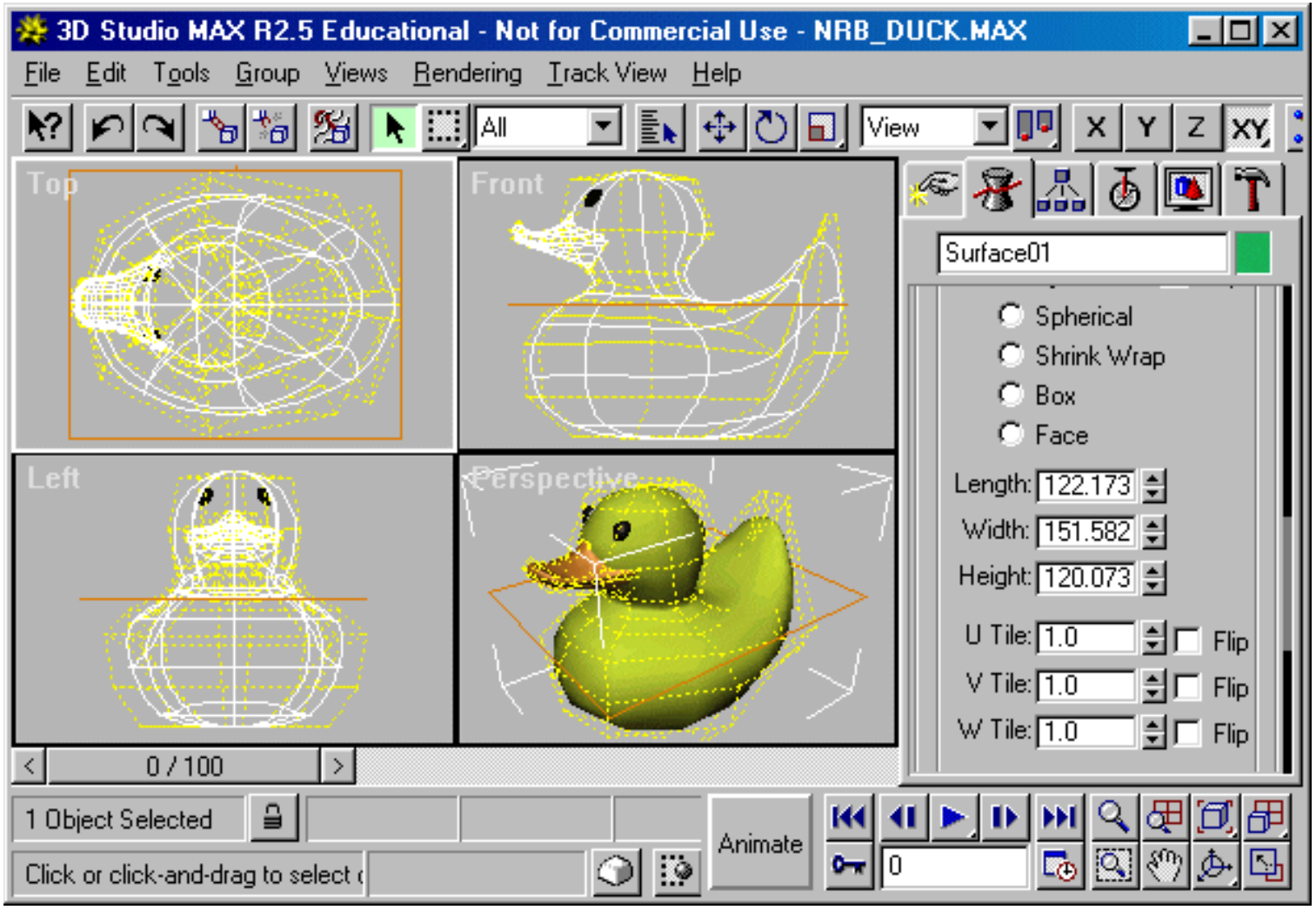
３次元モデリングは難しい！



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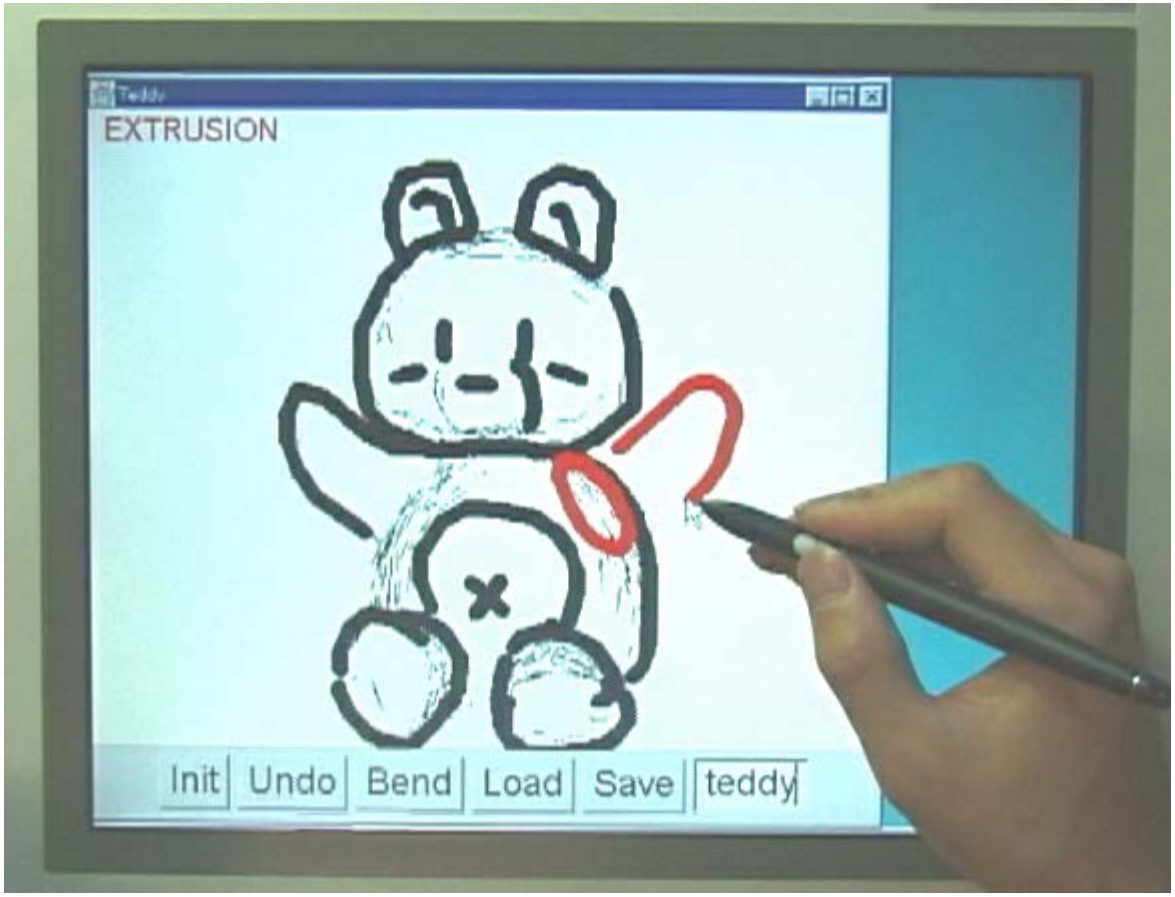
ペンでのスケッチは簡単



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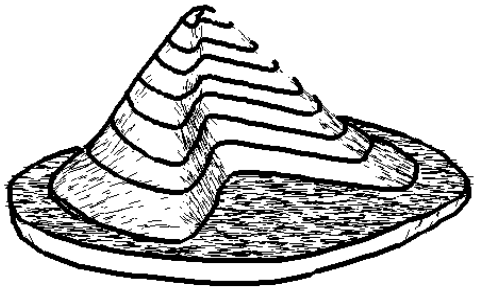
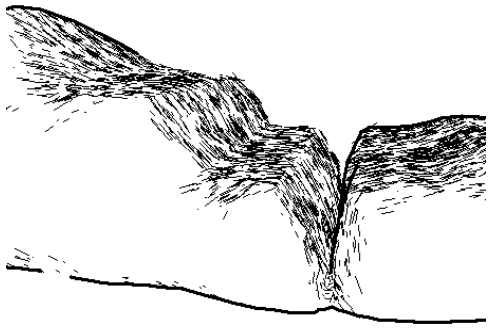
teddy

コミュニケーションへの応用

１）医学分野への応用
　　胃袋、歯、心臓などを３次元で表現

２）地形学習





五十嵐 健夫ほか「地形学習における手書き3次元モデリングの利用」
第109回情報処理学会 ヒューマンインタフェース・ 第52回音声言語情報処理共催研究会
2004年7月, pp.73-77.

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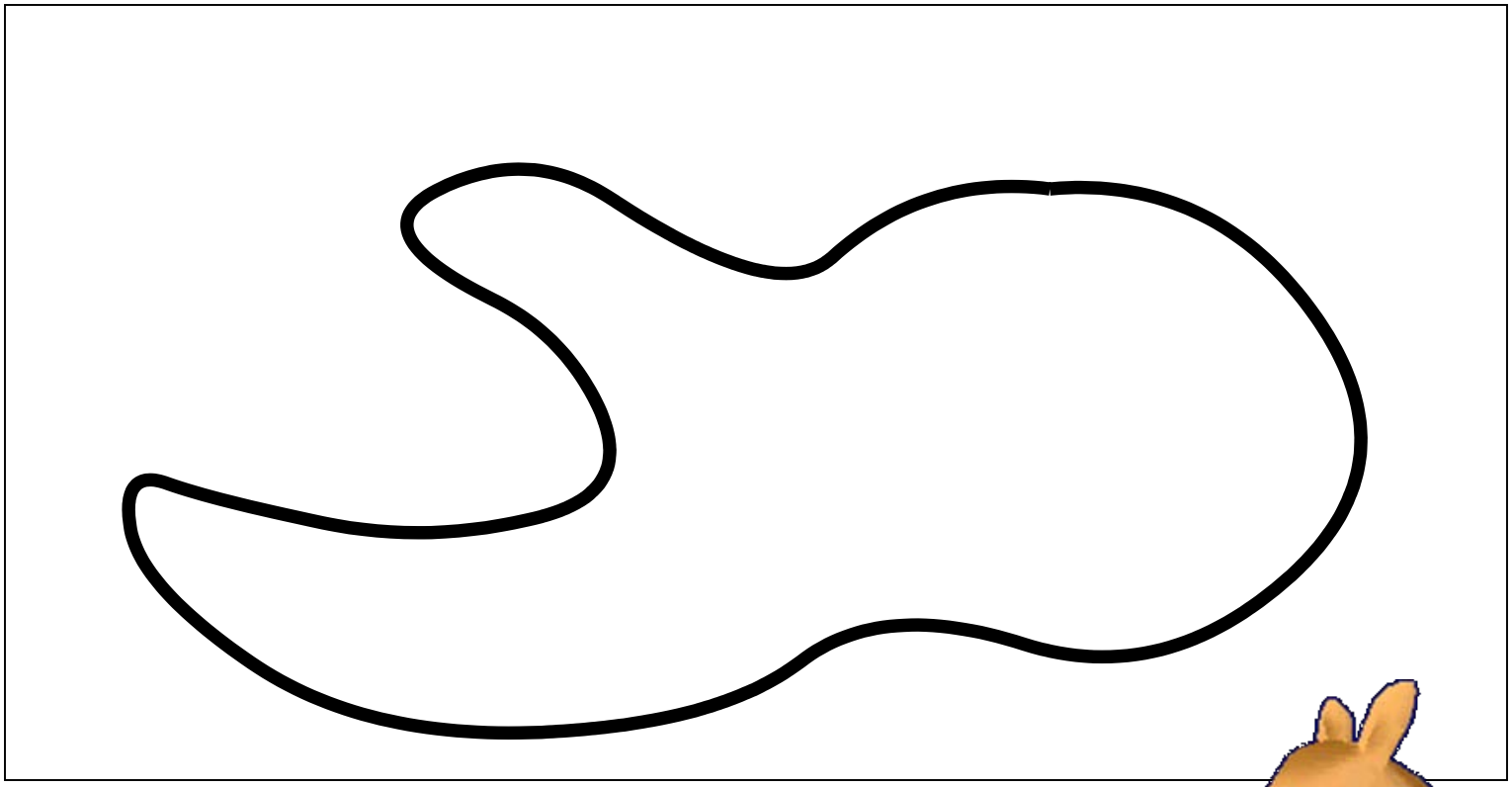
Algorithm



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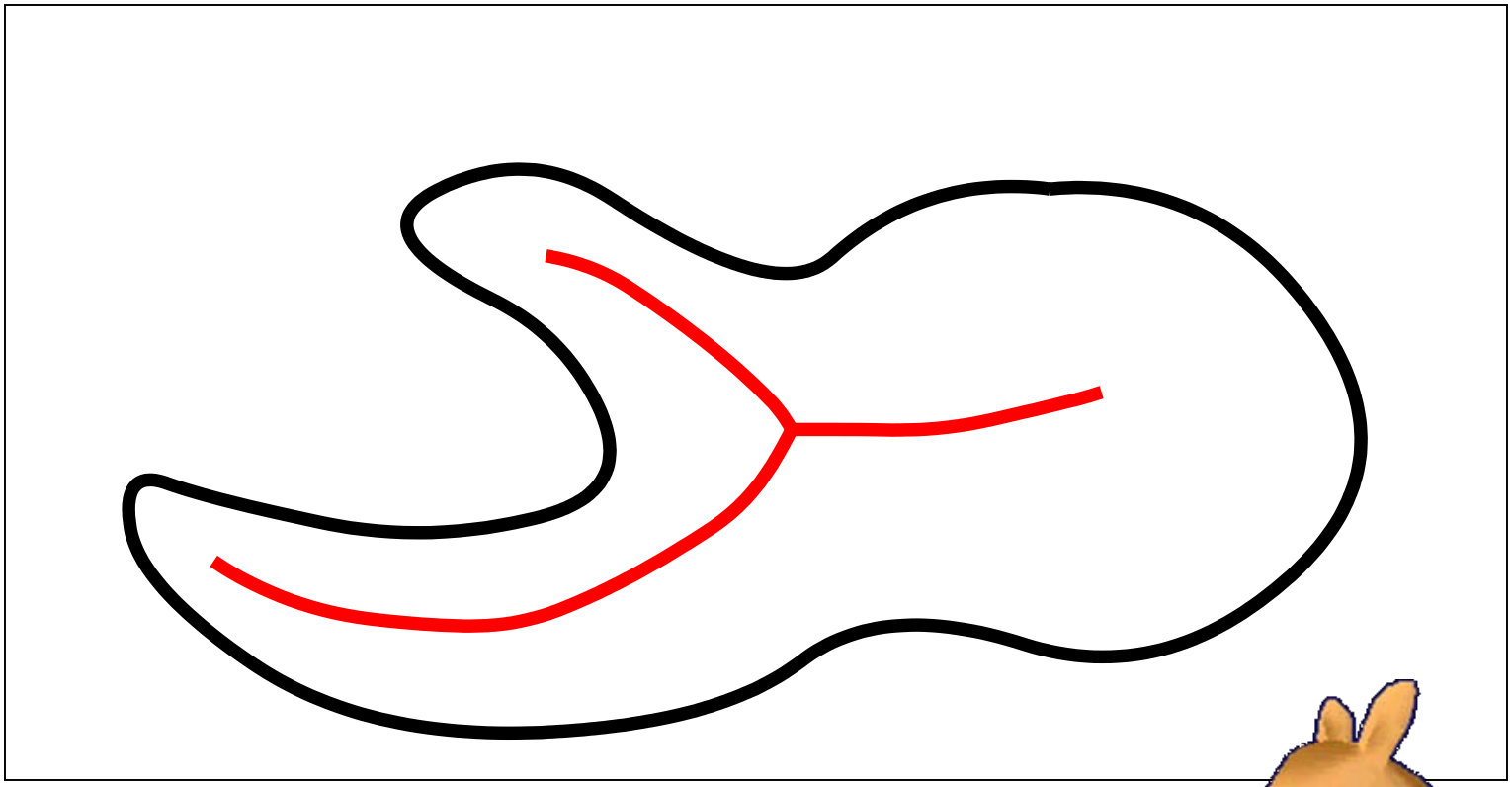
Algorithm



1. Find axes

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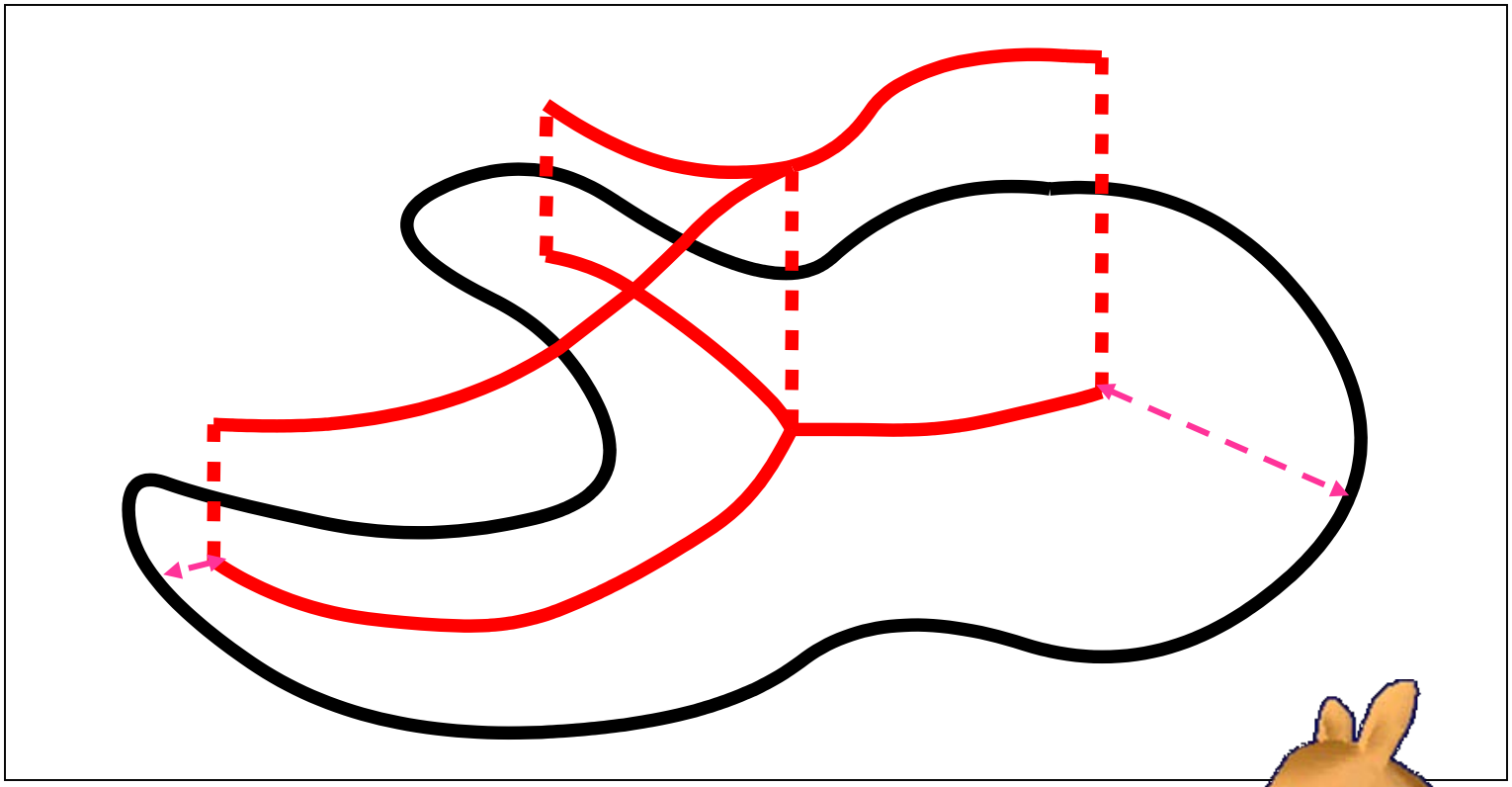
Algorithm



1. Find axes

2. Elevate axes

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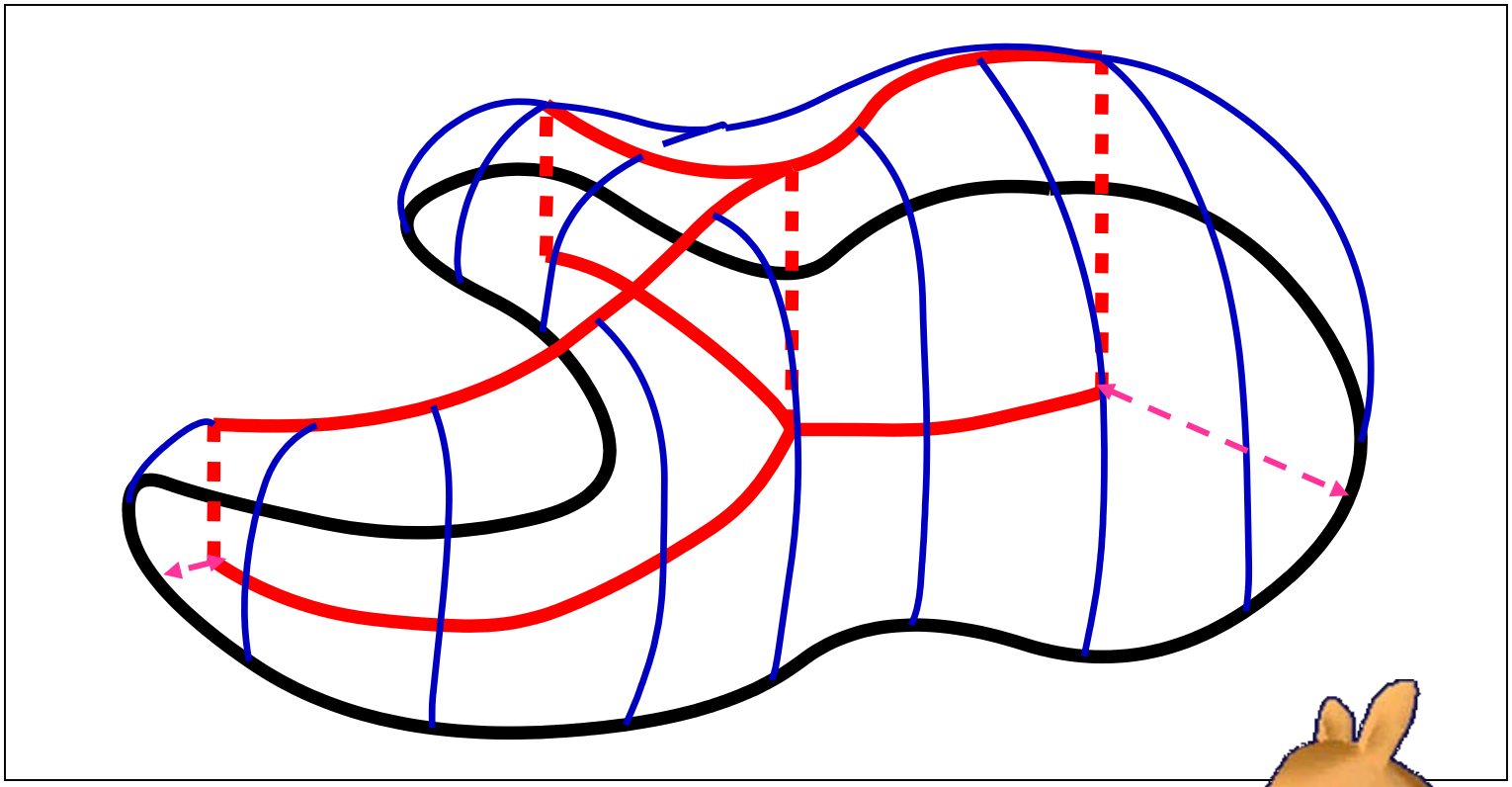
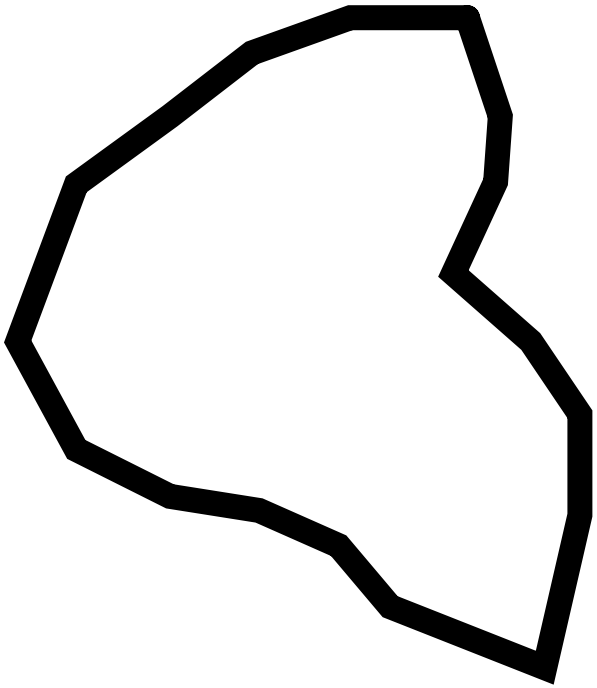
Algorithm



1. Find axes
2. Elevate axes
3. Wrap polygon and axes

20160623

Creation -Finding axes-



Input 2D polygon

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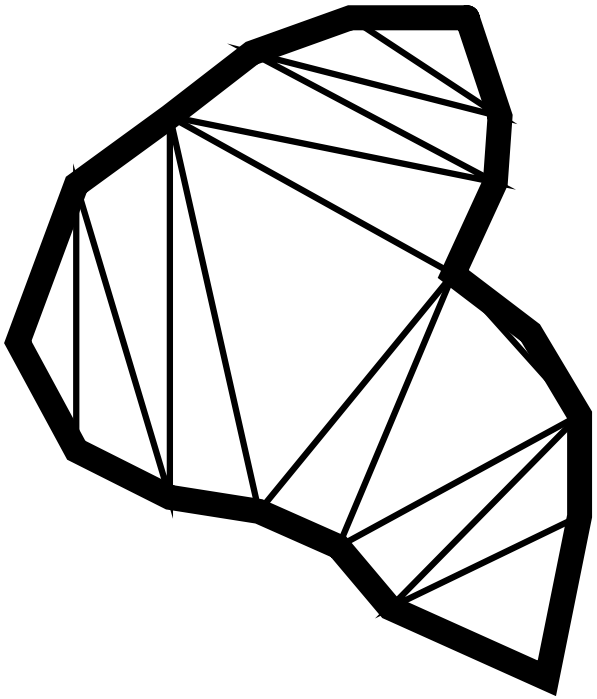
Creation -Finding axes-



Constrained Delaunay Triangulation

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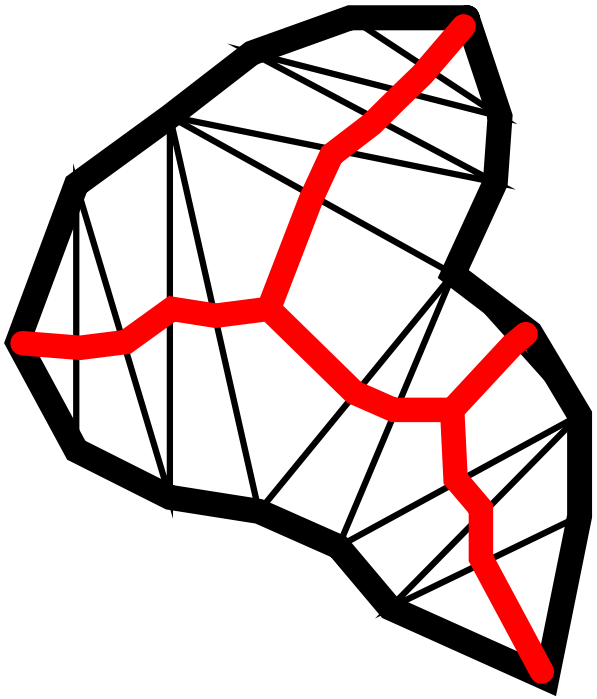
Creation -Finding axes-



Chordal axis (connecting mid-points)

[Prasad 1997]

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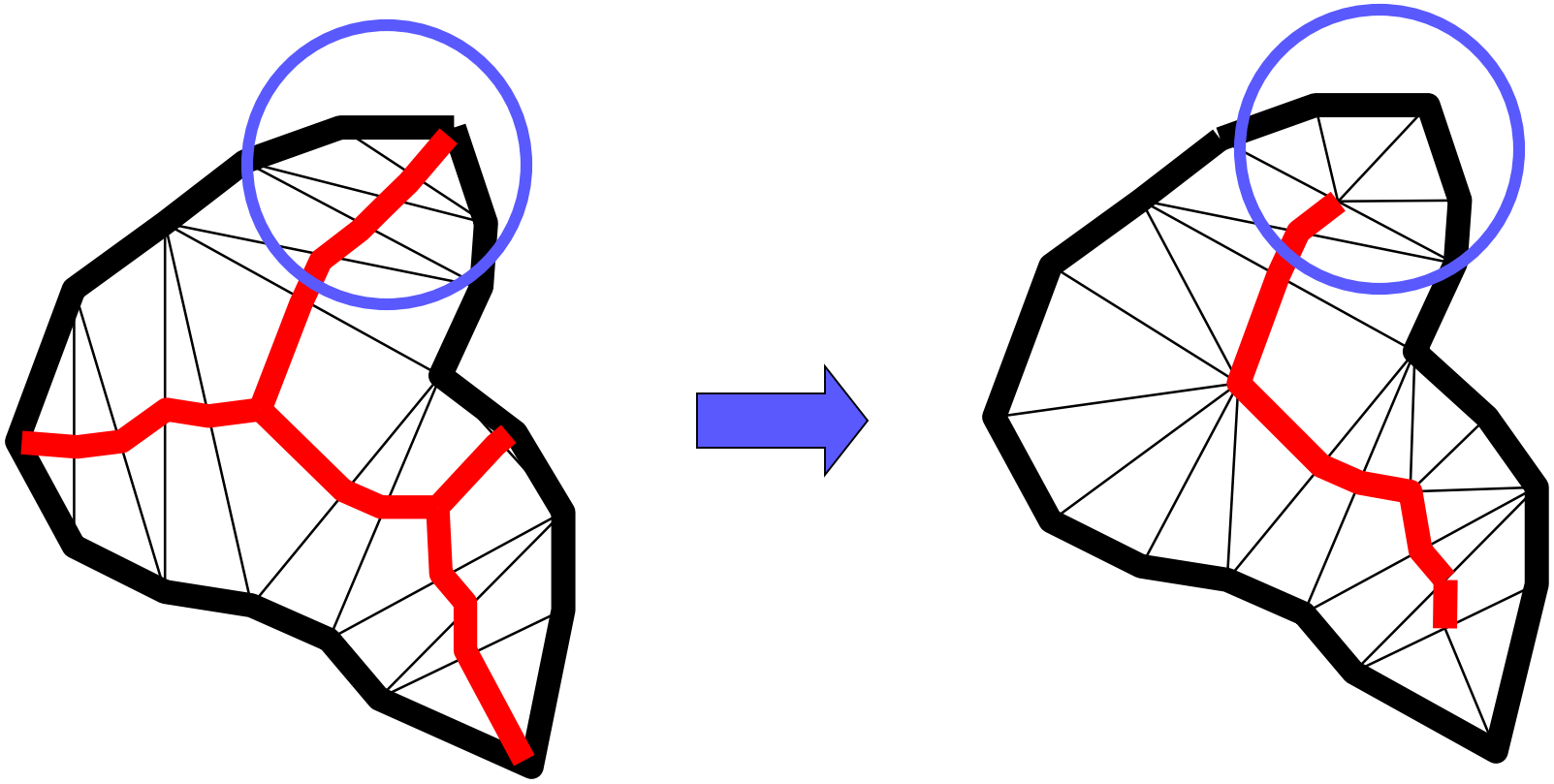
Creation -Finding axes-

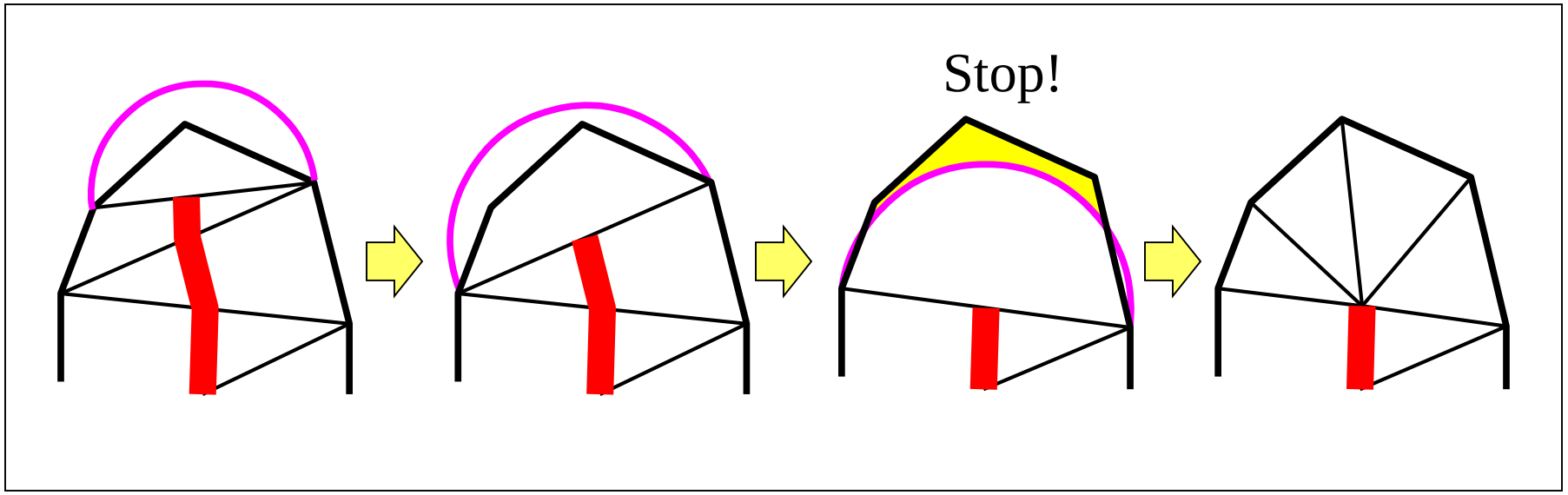


Before trimming

After trimming

20160623

Creation -Trimming-



Starting from each terminal,
search for the first significant edge.

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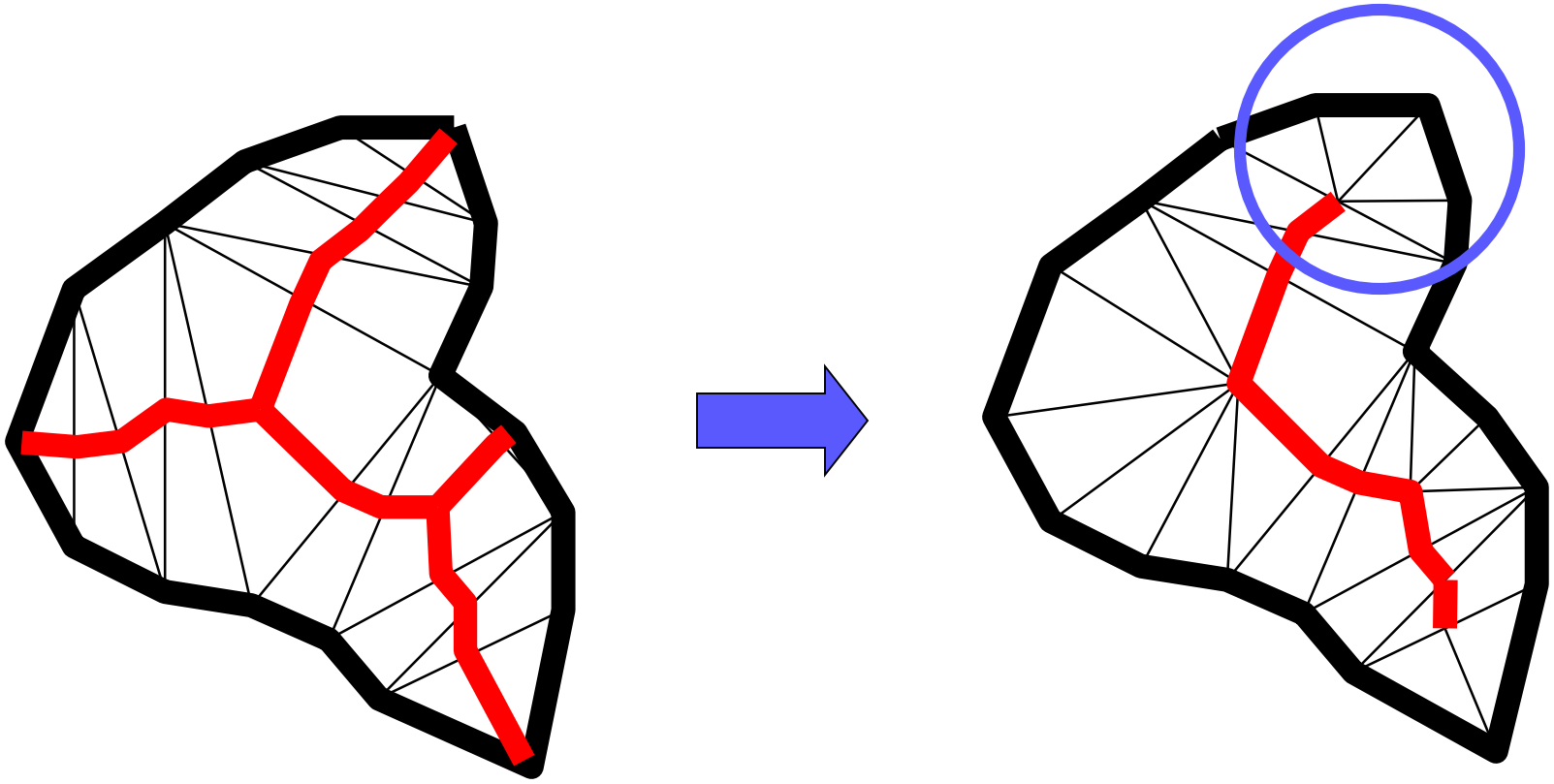
Creation -Finding axes-

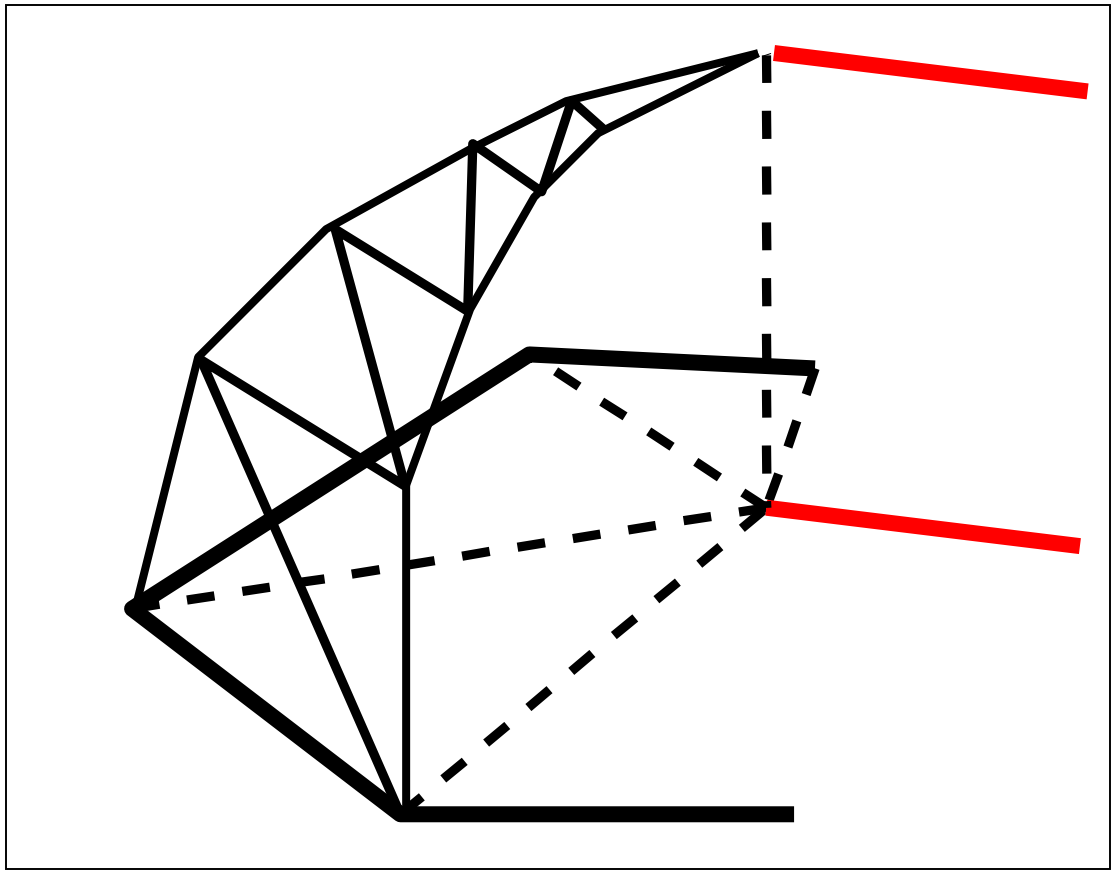


Before trimming

After trimming

20160623

Creation -Wrapping-



Lift the axes, and generate 3D faces along the spine.

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Products

PlayStation2

著作権等の都合により、ここに挿入されていた画像を削除しました。

ラクガキ王国
(2002年発売・Sony)

著作権等の都合により、ここに挿入されていた画像を削除しました。

ラクガキ王国
（2002年発売・Sony）

Nintendo GameCube

著作権等の都合により、ここに挿入されていた画像を削除しました。

カイジュウの島
(2004年発売・セガ)

著作権等の都合により、ここに挿入されていた画像を削除しました。

カイジュウの島
(2004年発売・セガ)

Package Software for PCs

著作権等の都合により、ここに挿入されていた画像を削除しました。
マジカルスケッチ

著作権等の都合により、ここに挿入されていた画像を削除しました。
マジカルスケッチ

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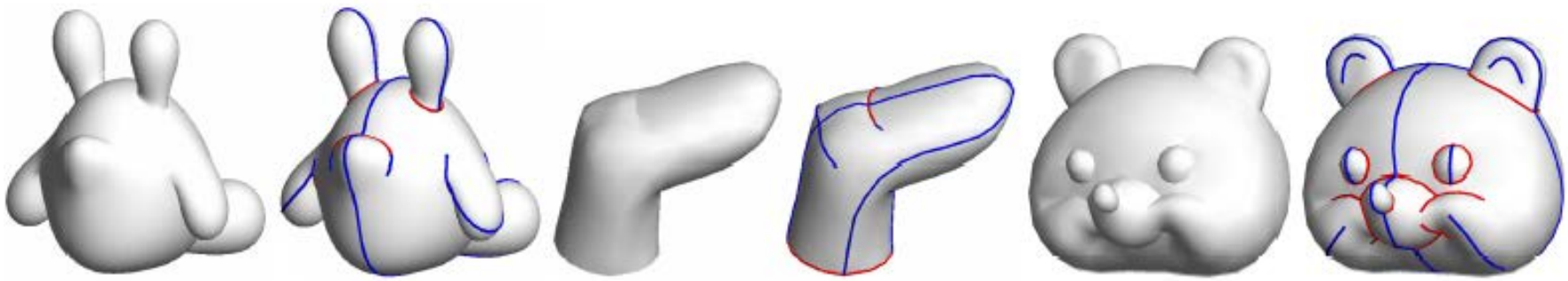
FiberMesh: Designing Freeform Surfaces with 3D Curves



"FiberMesh: Designing Freeform Surfaces with 3D Curves", ACM Transactions on Computer Graphics, ACM SIGGRAPH 2007, San Diego, USA, 2007
http://www-ui.is.s.u-tokyo.ac.jp/~takeo/papers/fibermesh.pdf, Figure 1

Nealen, Igarashi, Sorkine, Alexa

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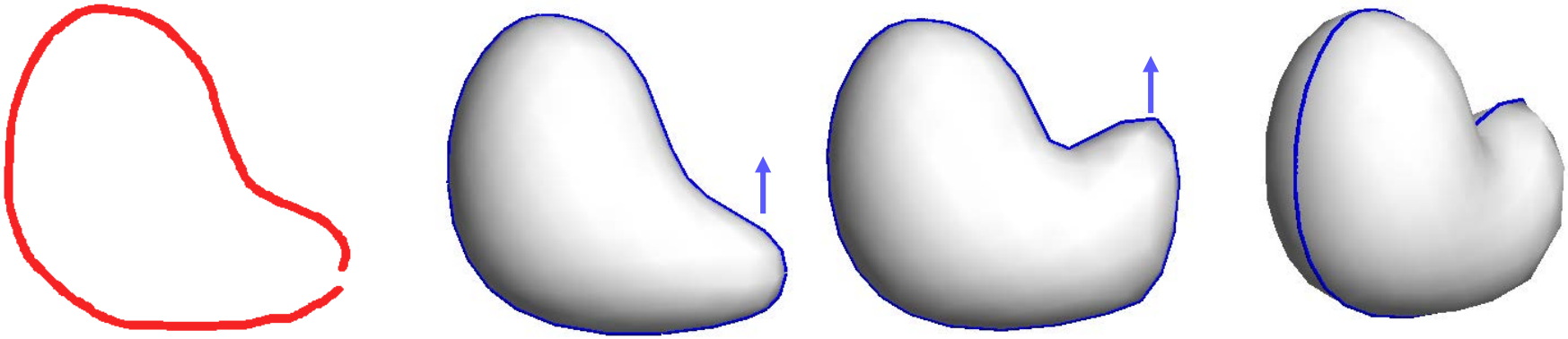
Designing with “Curves”

Original sketch stays and works as a handle.



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Demo

fibermesh

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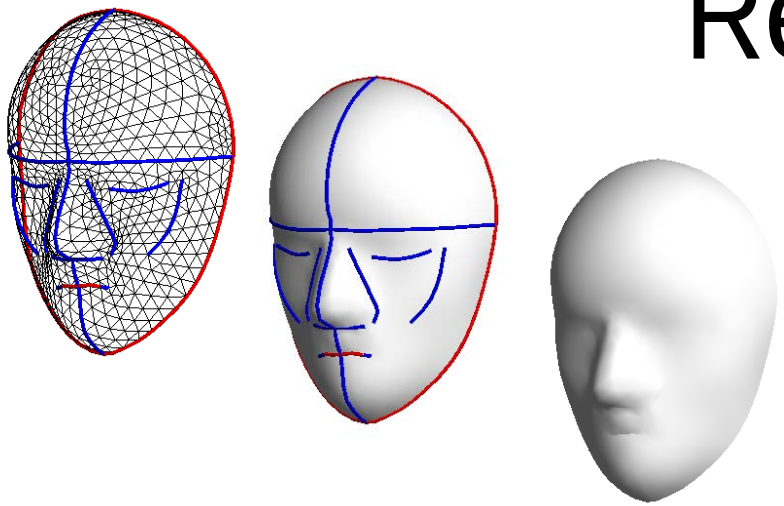
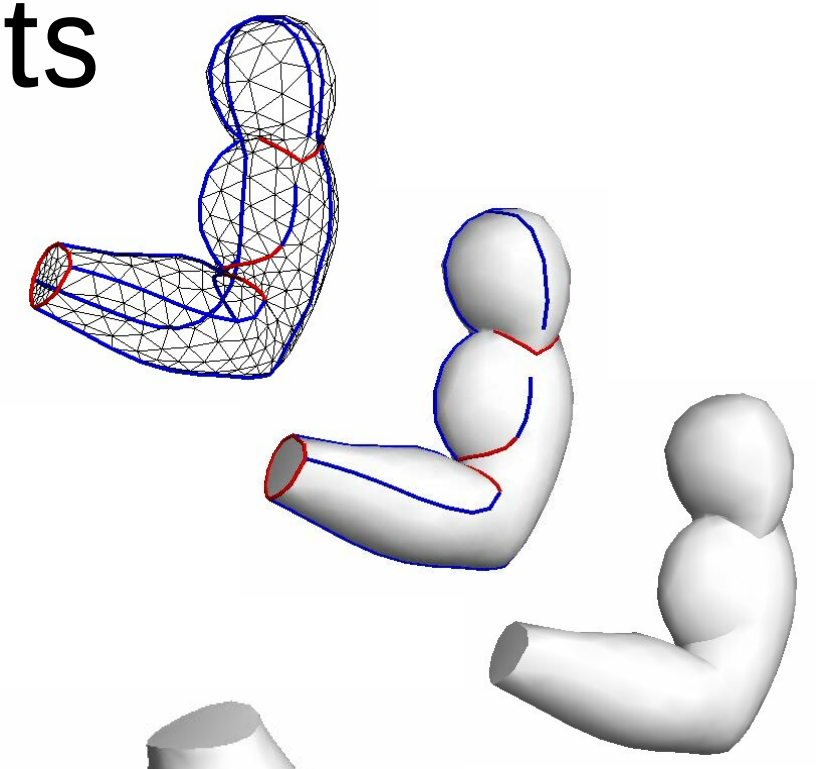
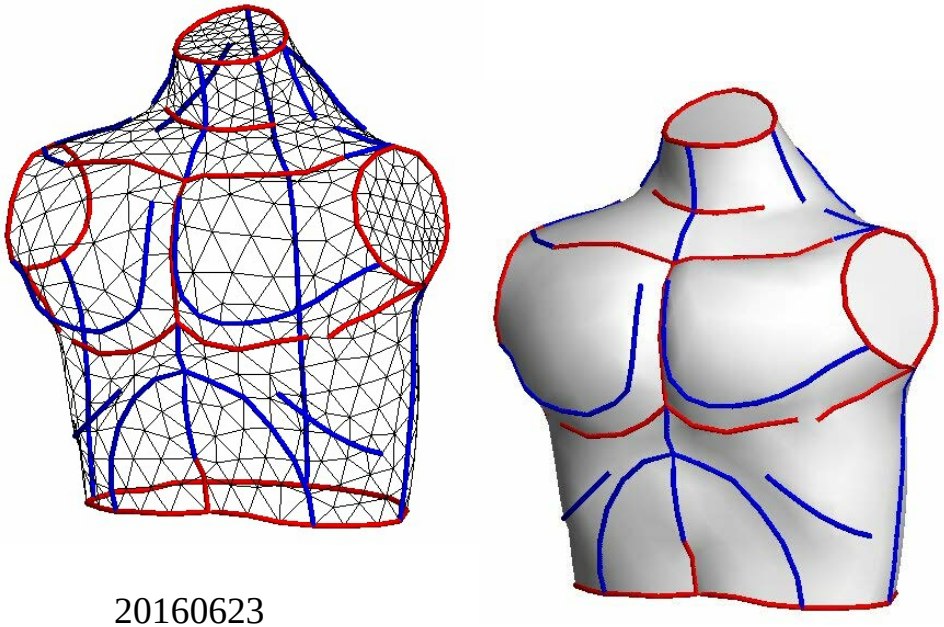
Results







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Algorithm

1. Curve Deformation
   Handle position -> Curve geometry

2. Surface Optimization
   Curve geometry -> Surface Geometry

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Computer-aided Design

- Plush Toys
- Beadworks
- Musical Instruments
- Garments
- Gliders

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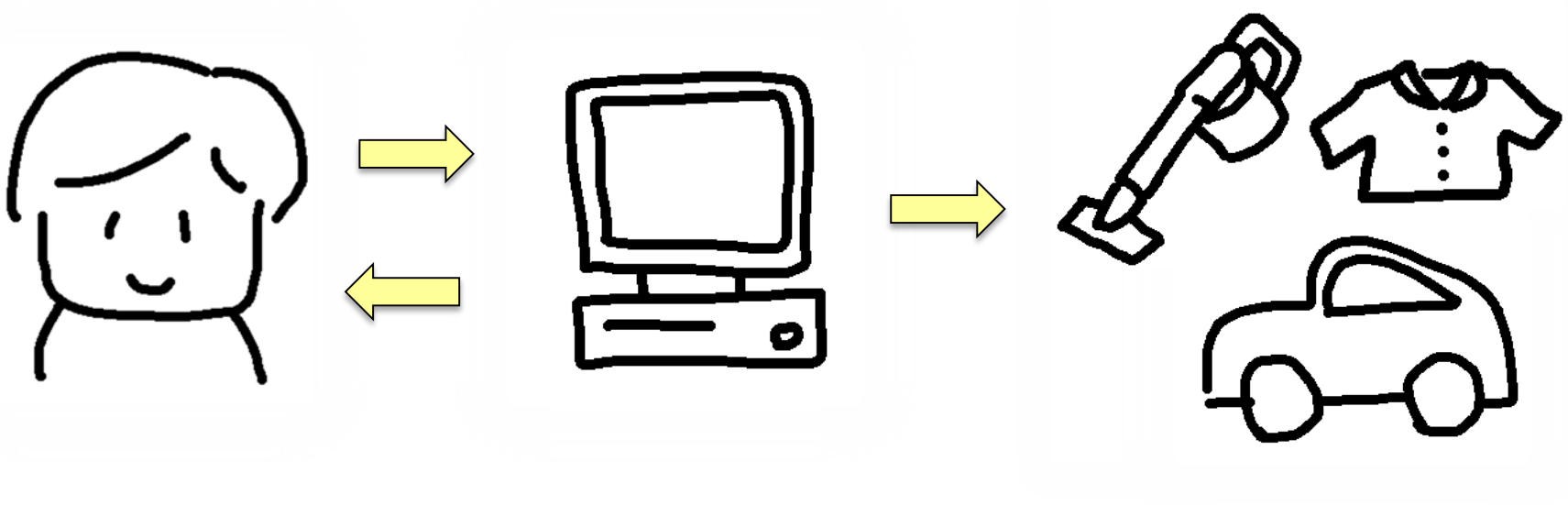
Computer-aided Design



Designer Computer Products

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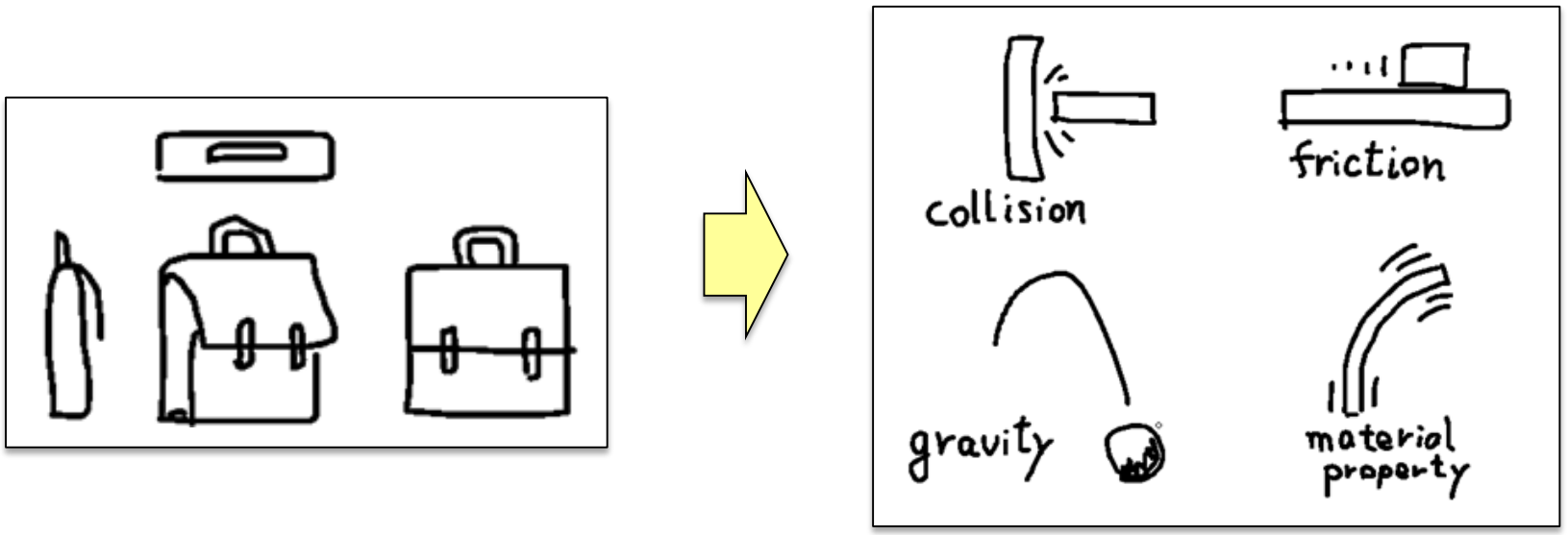
Traditional Approach

Modeling and simulation are separated.



Design
(Modeling)

Test
(Simulation)

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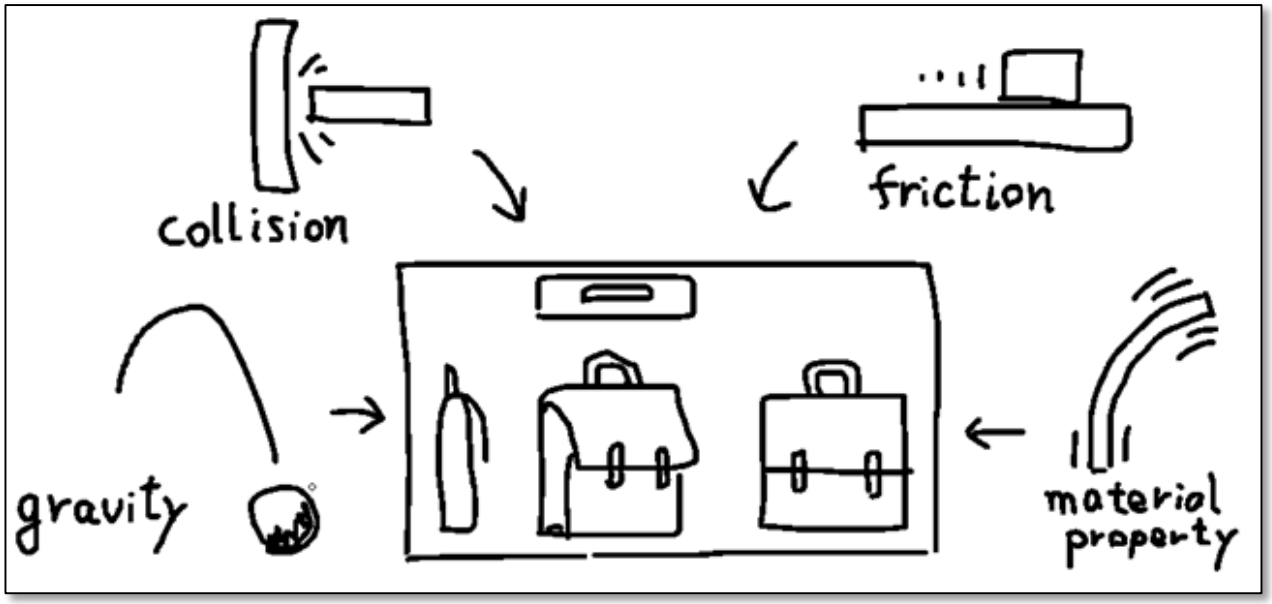
Our Approach

Integrate real-time physics into modeling.



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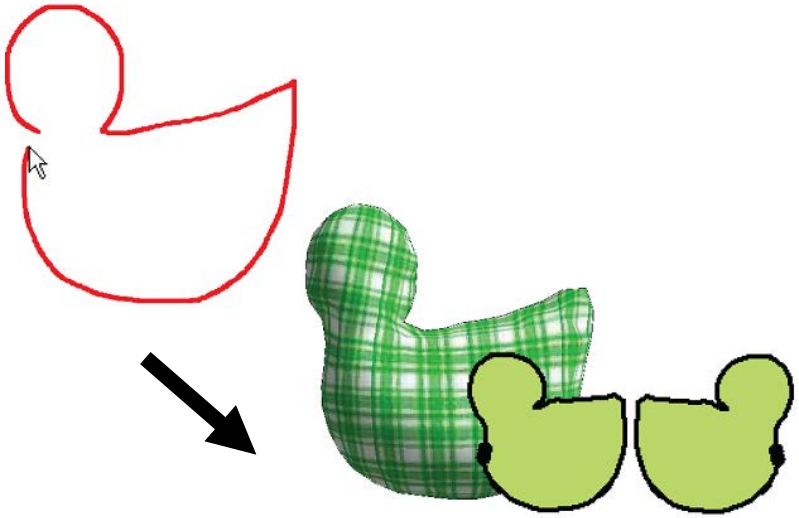
Our Approach



Automatically generate 3D model and cloth pattern for a sketch.

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Video

plushie.mp4

20160623

Algorithm

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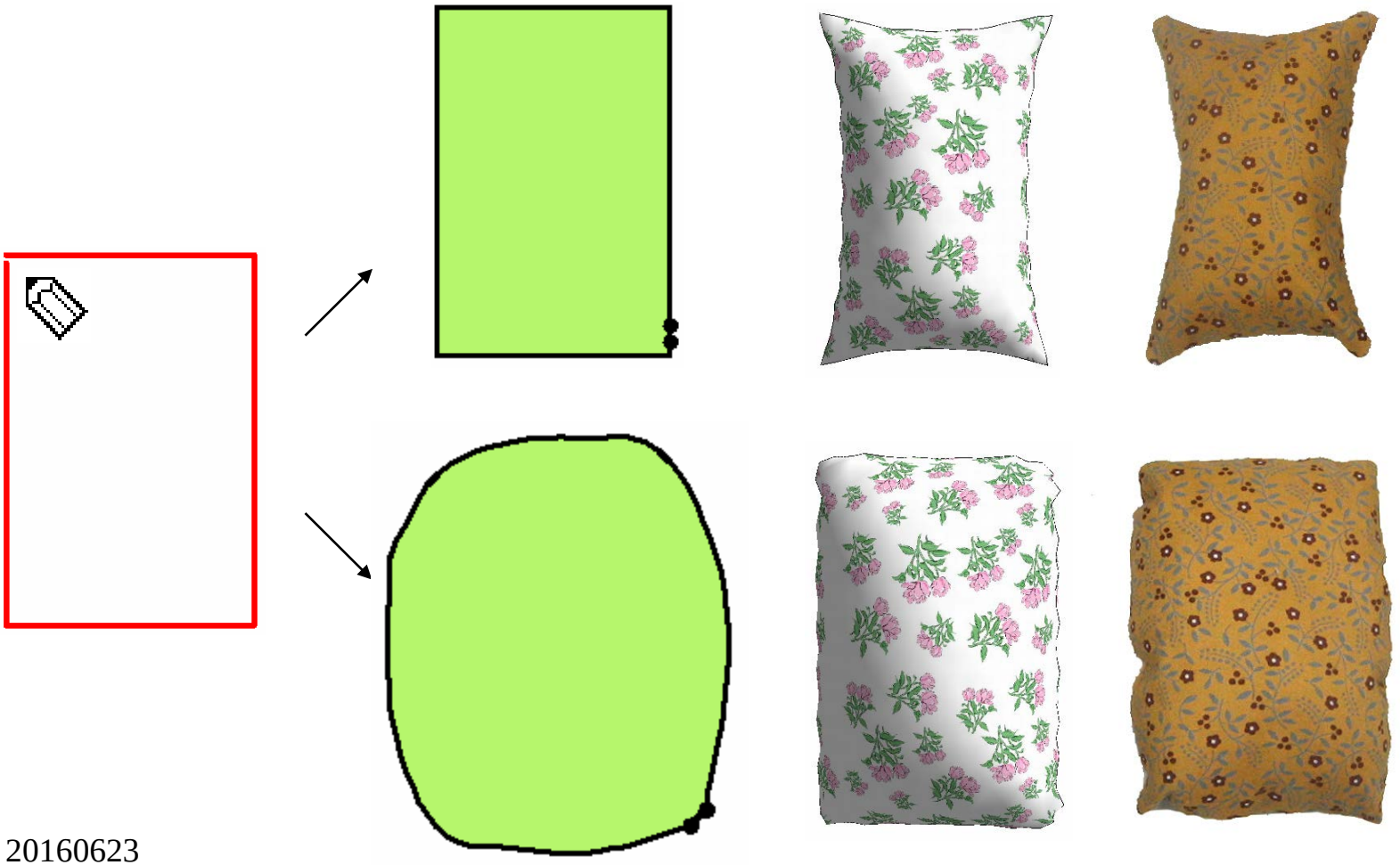
Physical Simulation & Shape Adjustment



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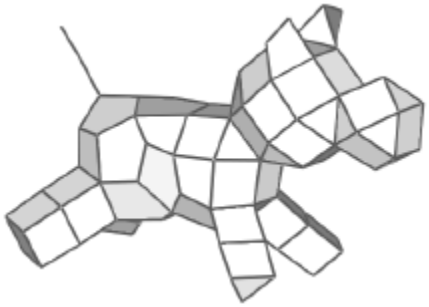
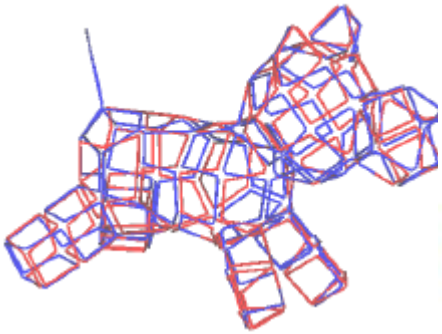
SIGGRAPH 2012

インタラクティブなビーズデザイン

Y. Igarashi and T. Igarashi

- ジェスチャー操作でビーズモデルをデザインする
- ワイヤーの通し方を自動で計算する
- 制作手順を分かりやすく表示する

demo beady

Problem to Address

- Beadwork is the art of connecting beads together by wires.

3D

著作権等の都合により、ここに挿入されていた画像を削除しました。

ビーズデザインプログラム図

The design and construction of 3D beadwork are very difficult !

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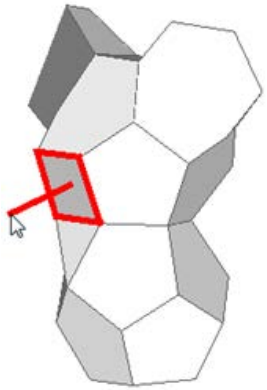
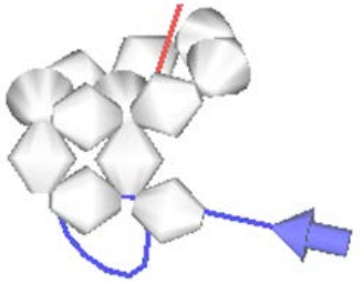
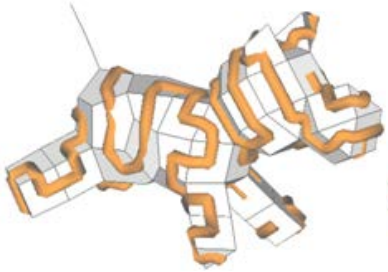
Our Approach

- Interactive Design and Construction





- Wire path planning algorithm



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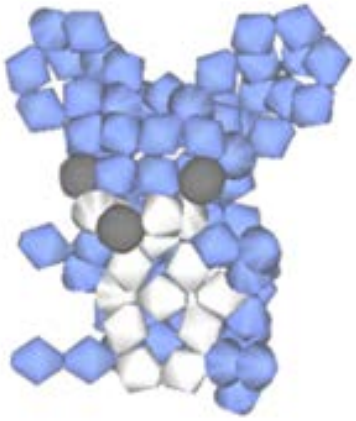
Demo



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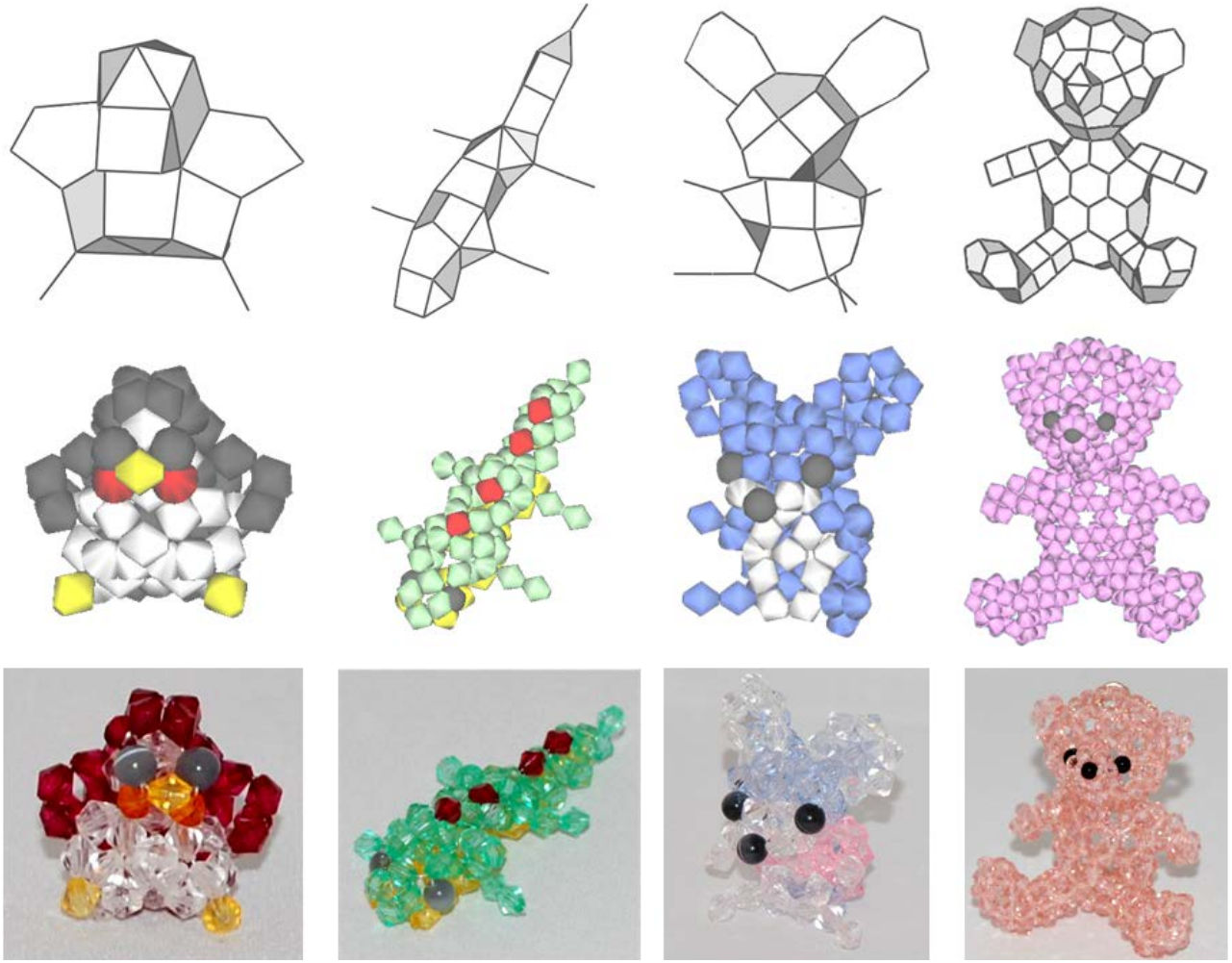
Examples



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Algorithm

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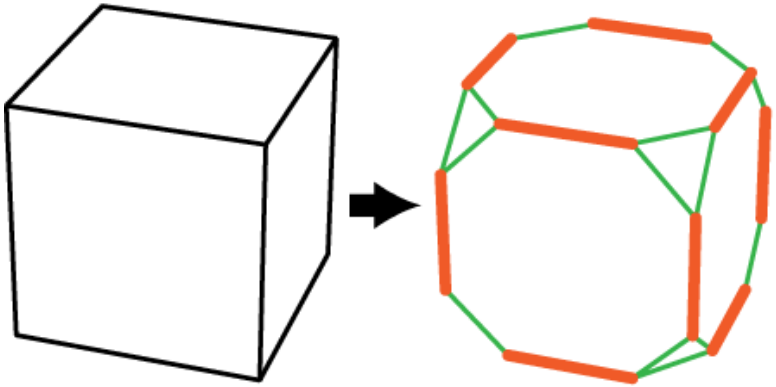
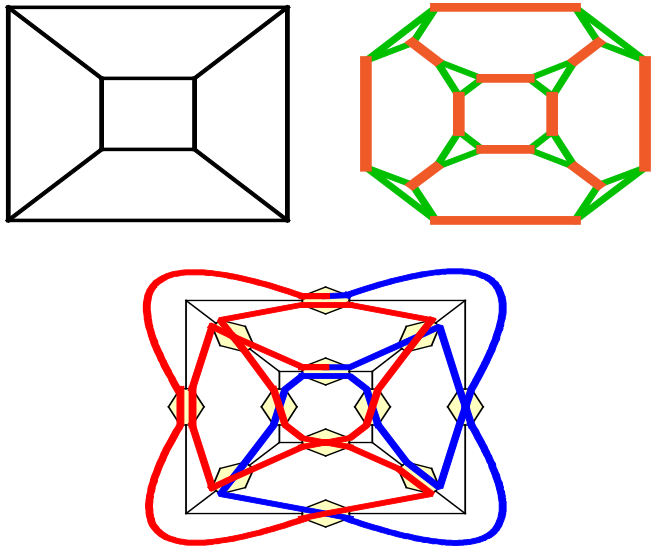
Computing Wire Path





- An edge corresponds to a bead
- A wire path is given as an Eulerian Circuit

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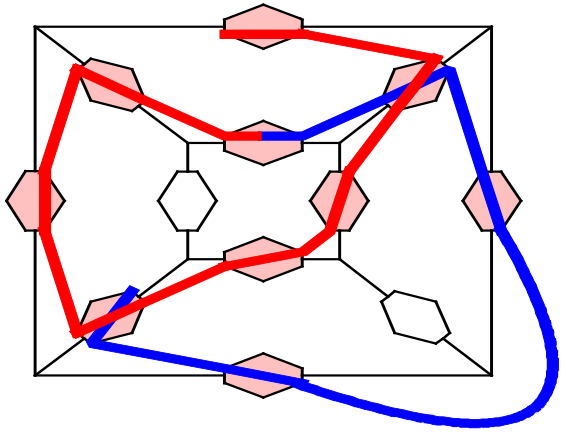
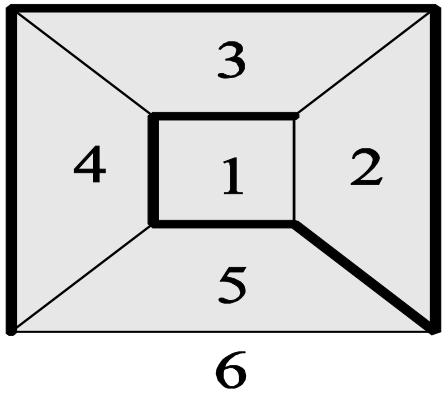
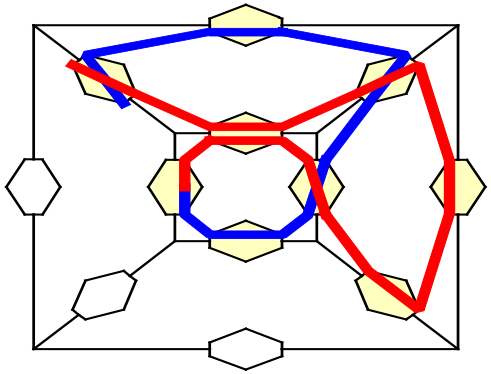
Computing Wire Path



unstable (dangling) beads



Face strip



Final wire path

- Arbitrary Euler cycle is not stable
- Make an Euler cycle along a face strip
- Face strip is given as a Hamilton path

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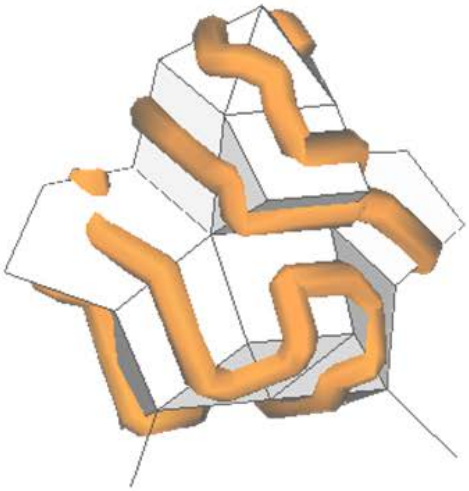
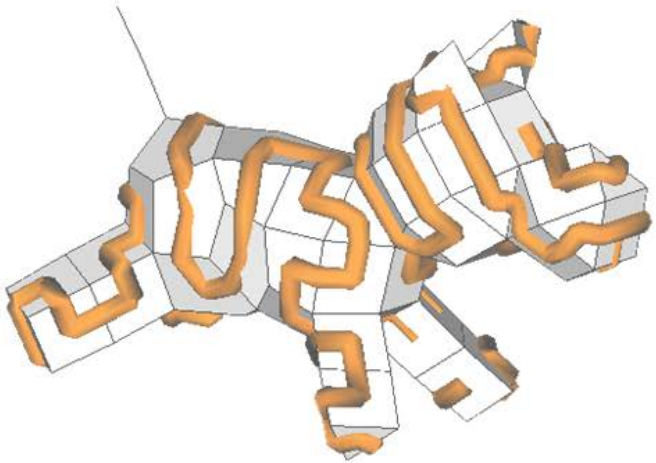
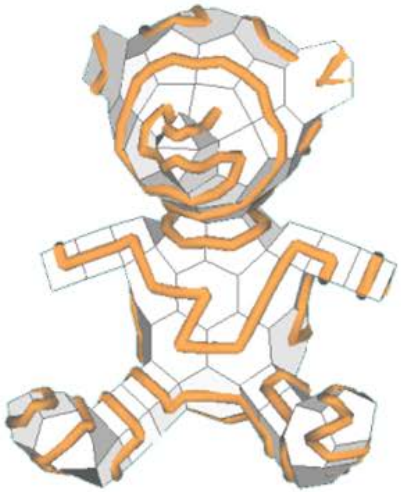
Stripification Results







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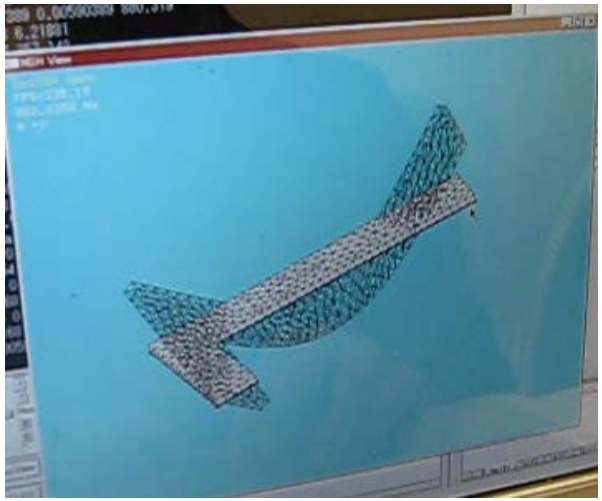
NIME 2010

Designing Custom-made Metallophone with Concurrent Eigenanalysis

N. Umetani, K. Takayama, J. Mitani, T. Igarashi



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Motivation

How to design an original musical instrument?

It is very difficult to find a shape that produce appropriate sound (tone).

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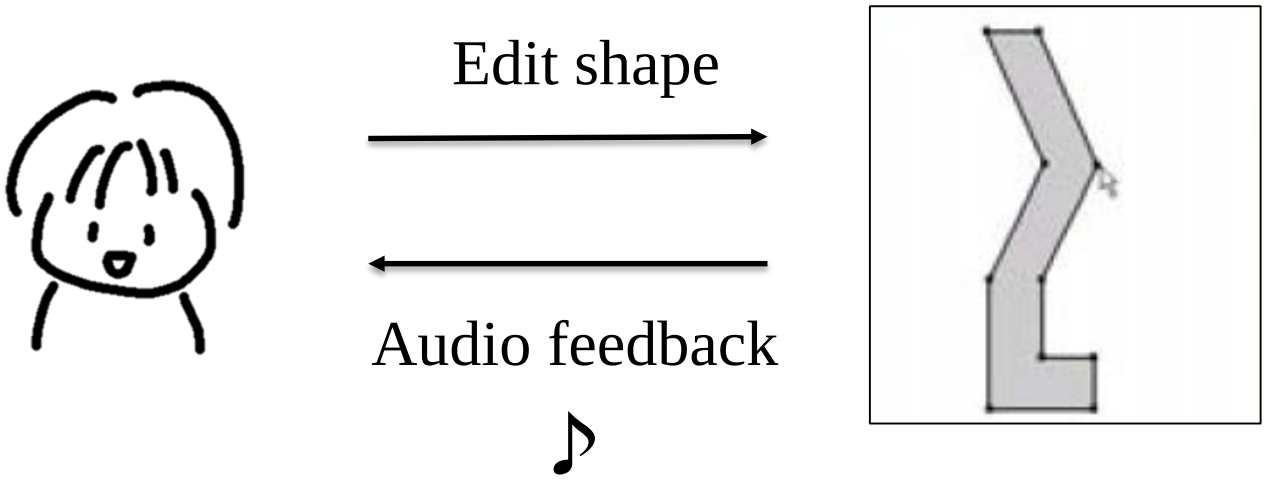
Our approach

Design system with continuous tone prediction.



The user edits the shape, and the system provides audio feedback.

20160623

Video

delfem.mp4

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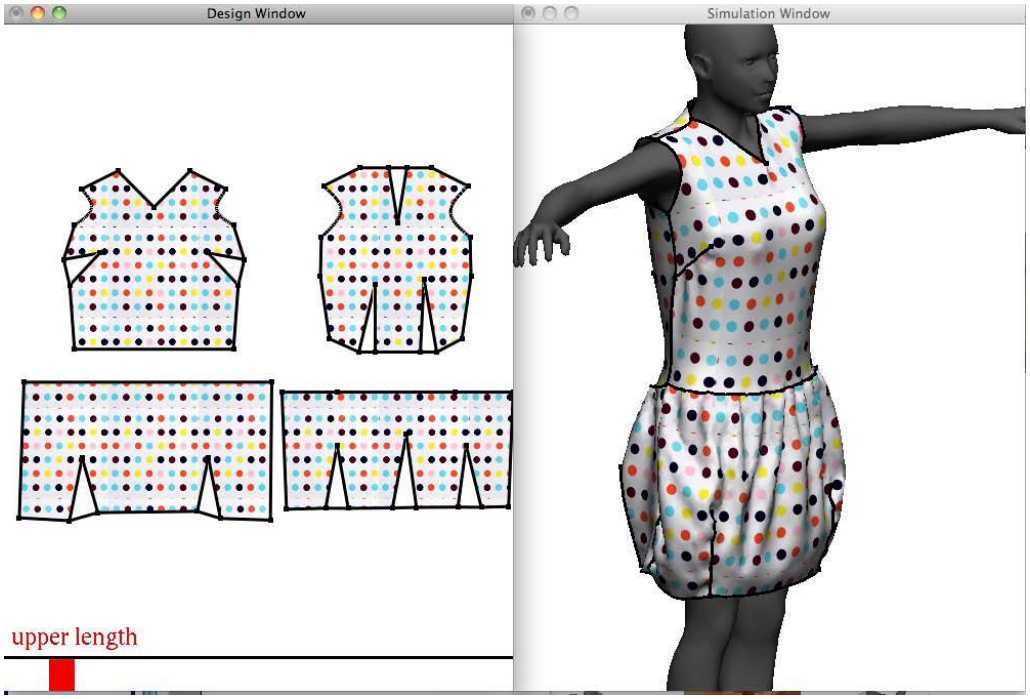
SIGGRAPH 2011

Sensitive Couture for Interactive Garment Editing and Modeling

N. Umetani, D. Kaufman, T. Igarashi, E.Grinspun



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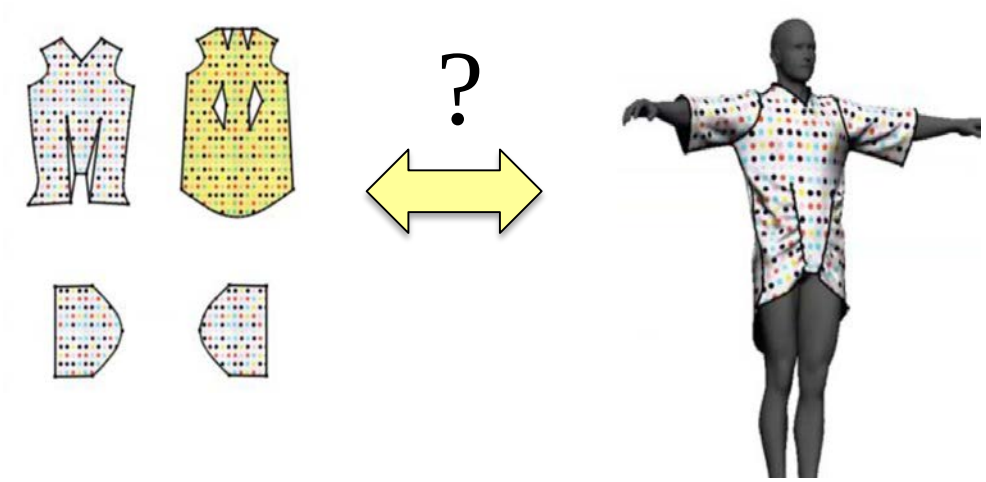
Motivation

How to design a new garment?



It is not easy to predict the result of draping

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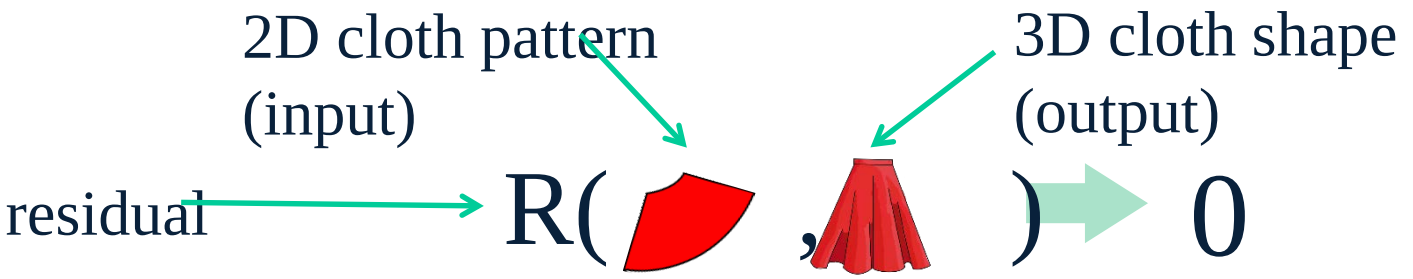
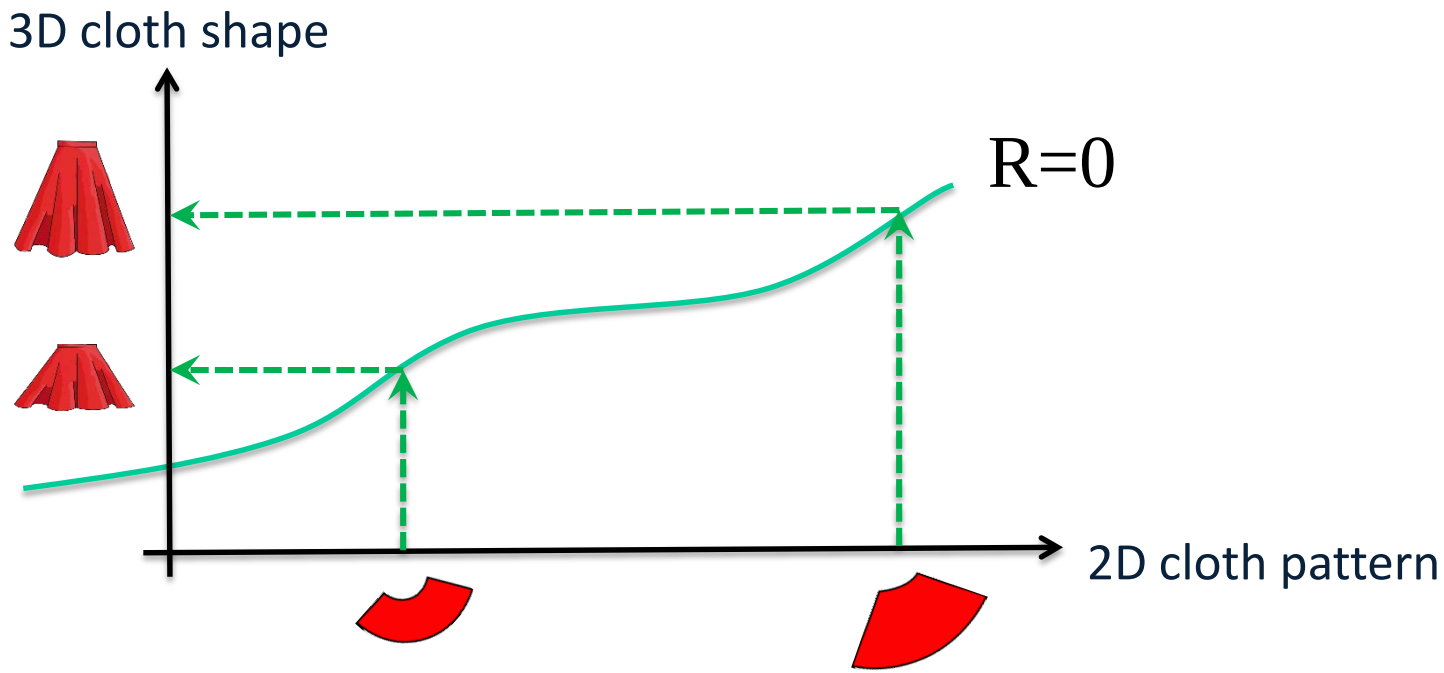
Video

cloth

20160623

Algorithm





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Our approach

Design system with continuous draping simulation.

User’s edit

Concurrent simulation result

The user edits the 2D pattern, and the system shows simulation result.

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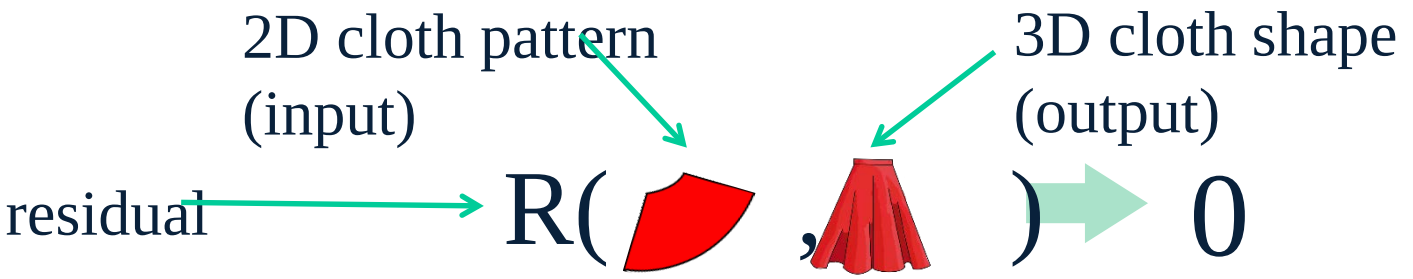
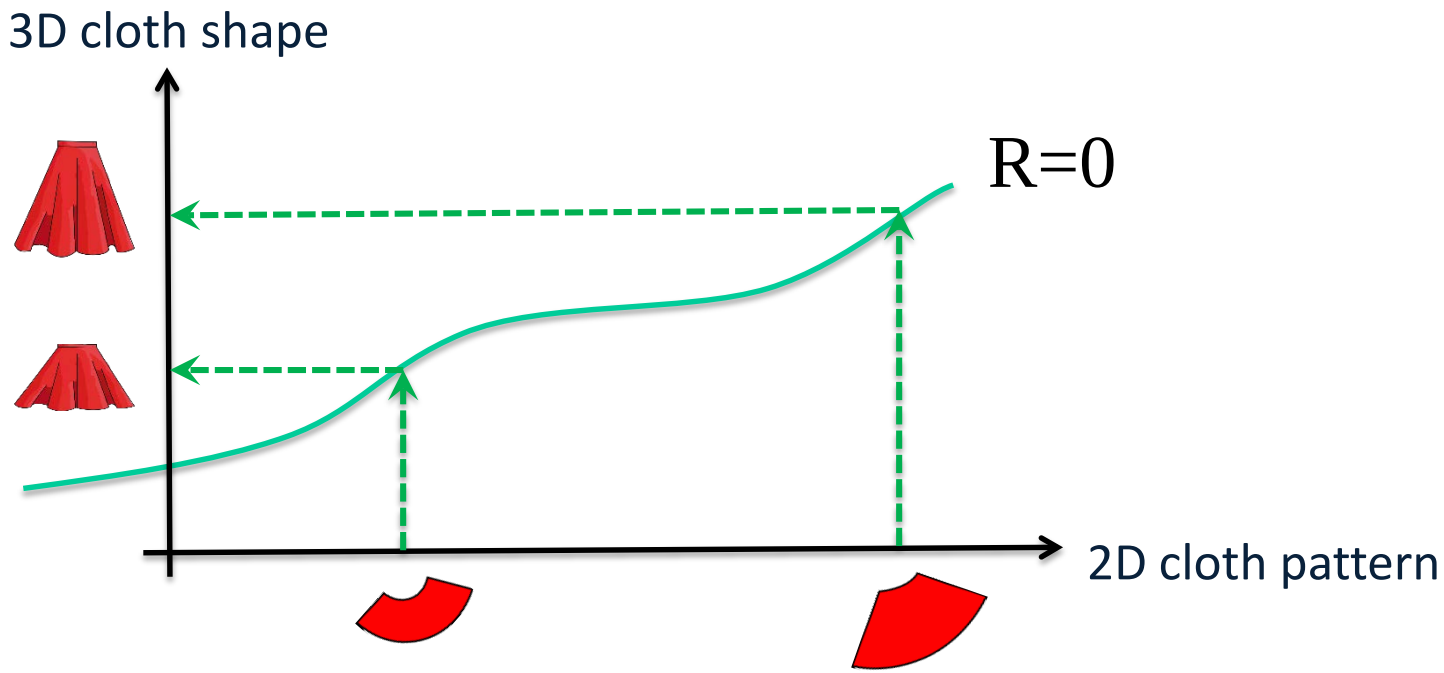
Algorithm





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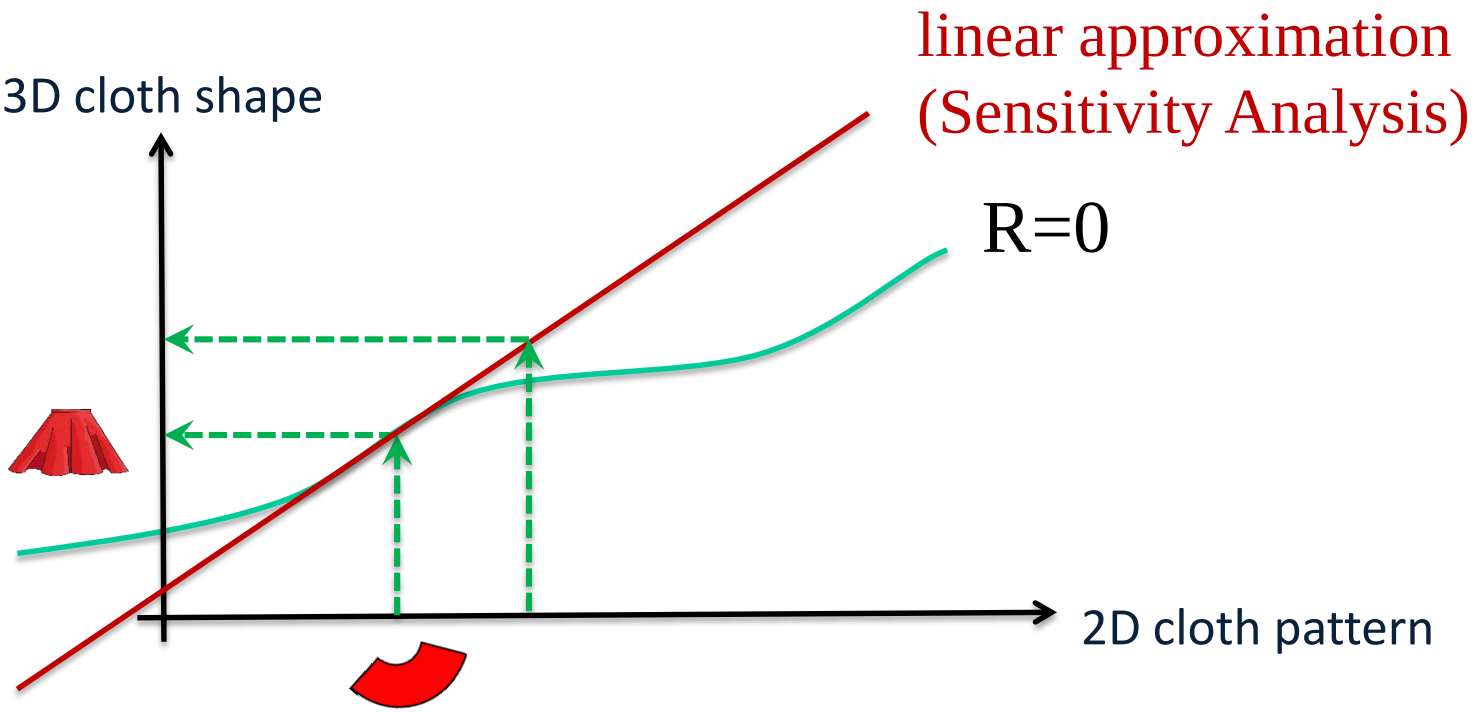
Algorithm

R is non-linear and slow to compute.
So, we use linear approximation around the current state.



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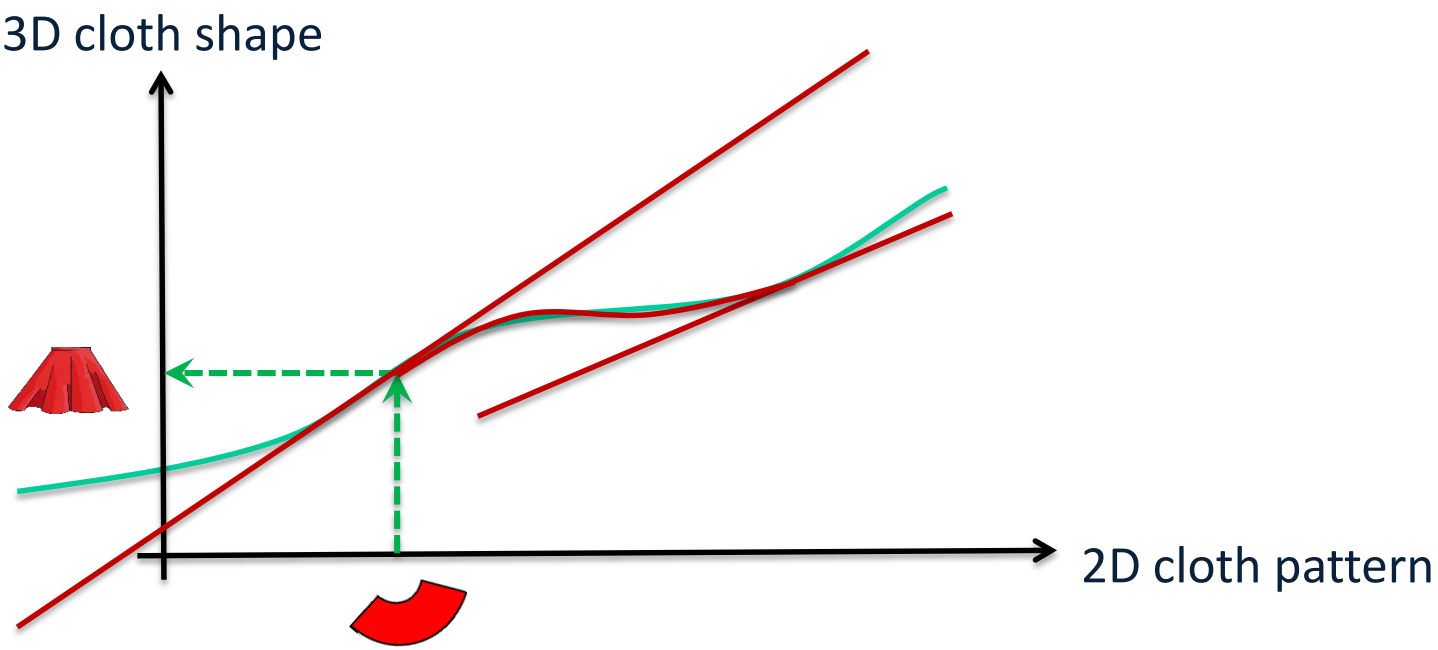
Algorithm

Single linear approximation is not enough.
We *cache* multiple linear approximations and blend them.



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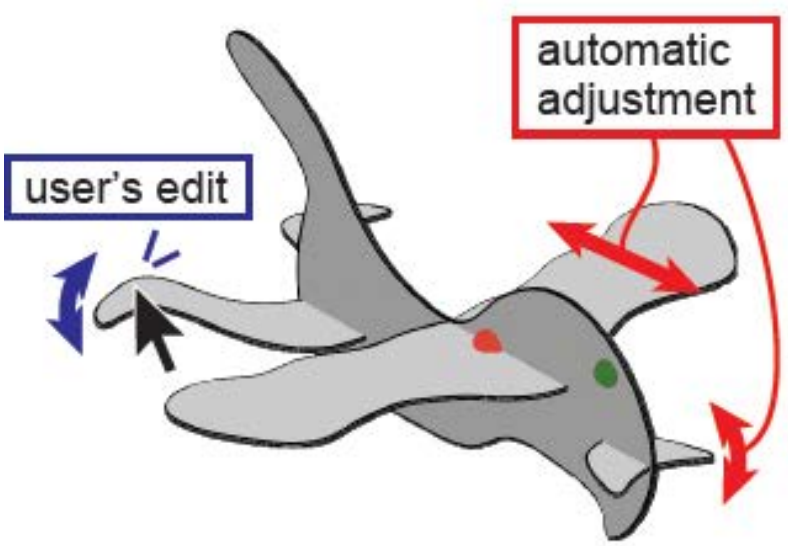
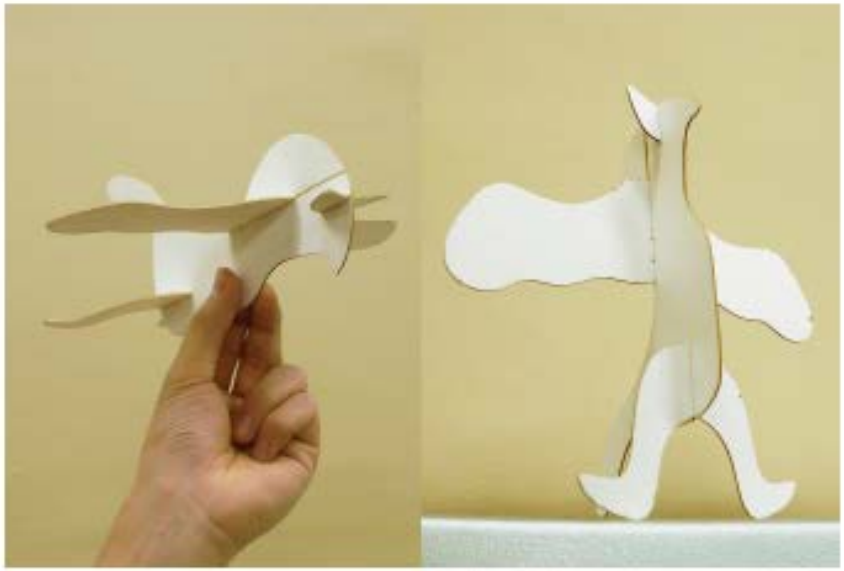
SIGGRAPH 2014

翼理論に基づく紙飛行機デザイン

with N. Umetani, S. Ryan, Y. Koyama





- 紙飛行機をデザインすると自動的に飛ぶように調整する。

video

Motivation

How to design a paper airplane (glider)?

著作権等の都合により、ここに挿入されていた画像を削除しました。

模型グライダー各種

It is not easy to design a glider that flies well.

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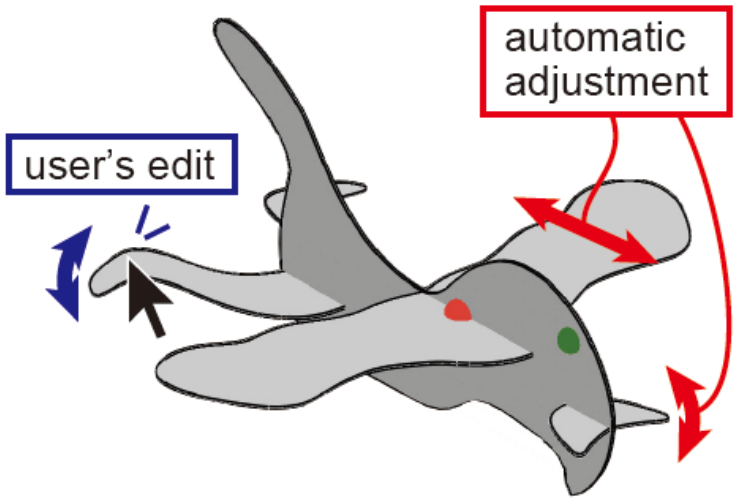
Our approach



Continuous simulation.

+

Automatic optimization.

20160623

Data-driven Approach

Accurate, analytic simulation is difficult.

⇒ We use many measured “data”.

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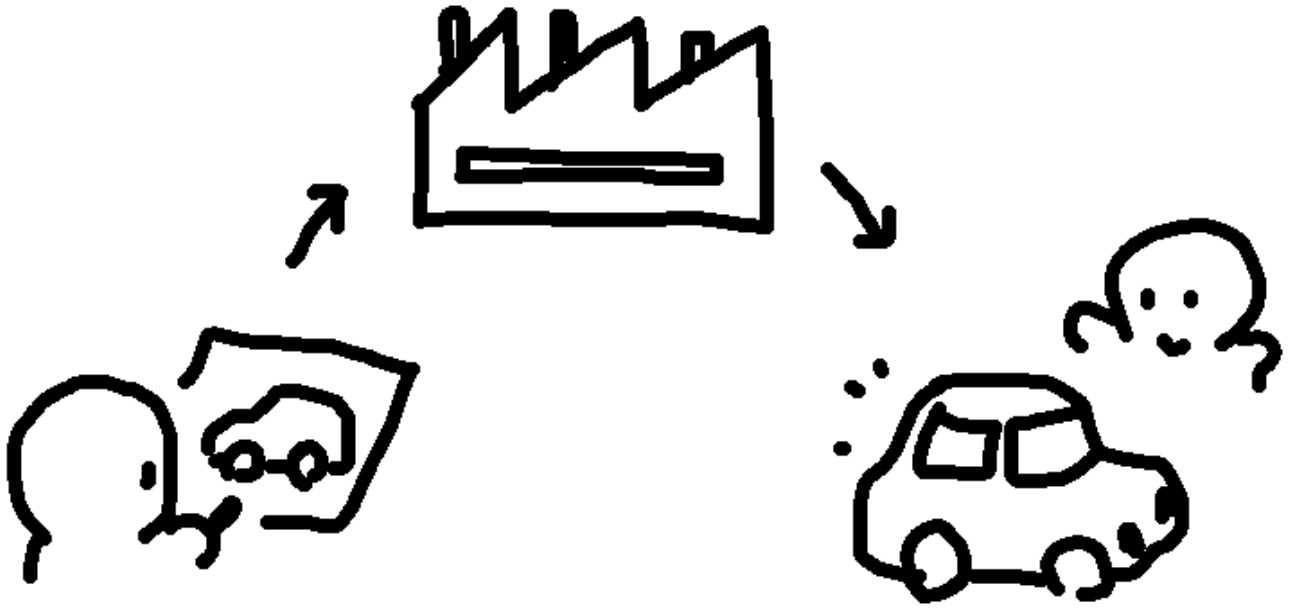
Video

pteromys

20160623

Future Vision



Design Everything !

Furniture, Clothing, Car, House...

20160623

おわり

デモソフトやビデオなどは以下で配布しています
http:// www-ui.is.s.u-tokyo.ac.jp/~takeo
http://www.jst.go.jp/erato/igarashi/

20160623

