Subdivision-Based Representations for Surface Styling and Design

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DIMACS'03

Motivation

IBM-Dassault-NYU collaboration

Address limitations of NURBS

- Arbitrary topology
- Multiple resolutions
- Efficient transition from styling to class A surfaces

Interactive styling operations

Integration into CATIA

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Outline

Subdivision surfaces

- Catmull-Clark subdivision
- Multiresolution

Modeling operations

- Surface pasting
- Engraving, embossing, trimming
- Free-form variational design

Conversion / remeshing

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Subdivision

- subdivision = repeated refinement

- many attractive features:
  - ✓ arbitrary topology
  - ✓ scalability, LOD
  - ✓ uniformity
  - ✓ code simplicity, etc

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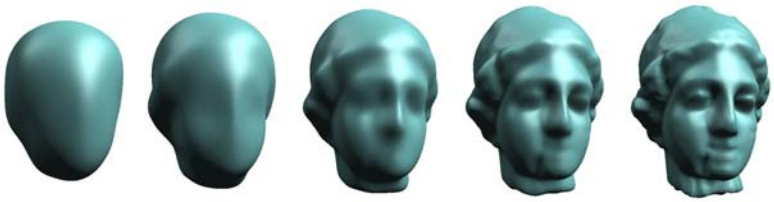
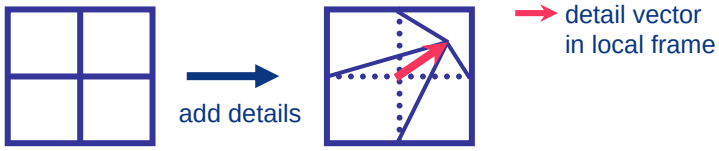
Multiresolution Subdivision

- multiresolution = subdivision + details





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Surface Pasting

(SIGGRAPH 2002)

With Henning Biermann and Denis Zorin (NYU)

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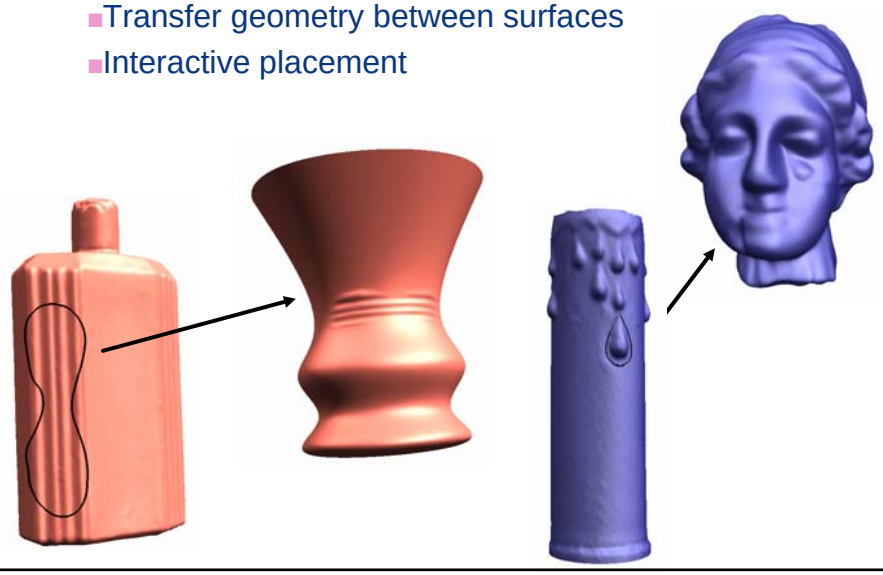
Surface Pasting

- Transfer geometry between surfaces
- Interactive placement



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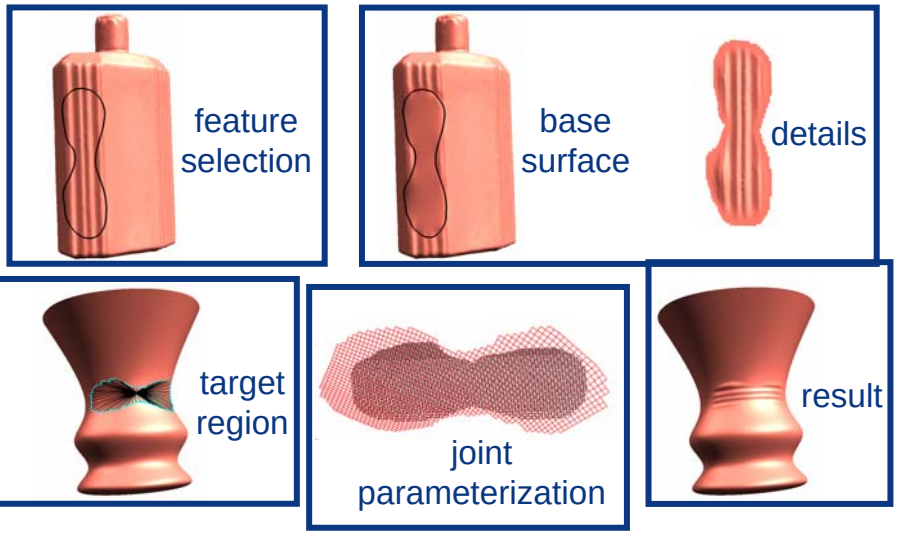
Method Overview



Base / Detail Separation

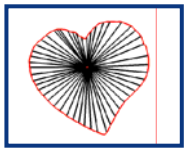
- Controlled by a single parameter: flatness
- Smoothly varying from soapfilm to the original surface
- Use soapfilm surface to get a flatter base than the coarsest level
- Use fitting/quasi-interpolation at different subdivision levels to get discrete set

Target Region Finding

Problem

- Find the target region for pasting
- Closely match feature size and shape

source: selected region



boundary parameterization

target region

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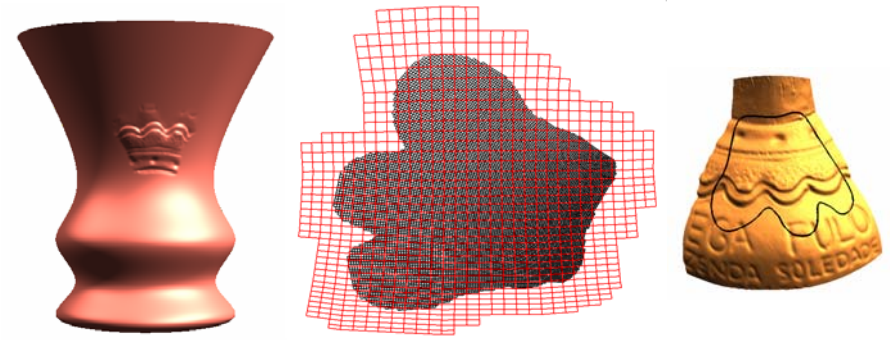
Parameterization

- Approach: parameterize both source and target onto a plane
- Requirements: one-to-one, minimize distortion, free boundary



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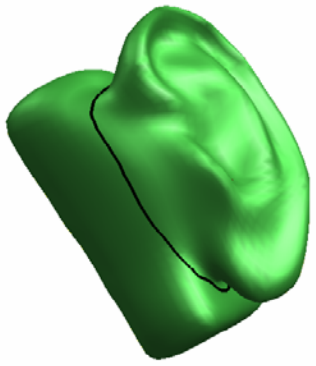
Demo



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Sharp Feature Editing

With Henning Biermann and
Denis Zorin (NYU)

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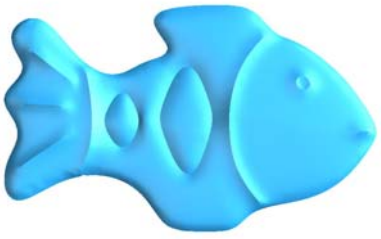
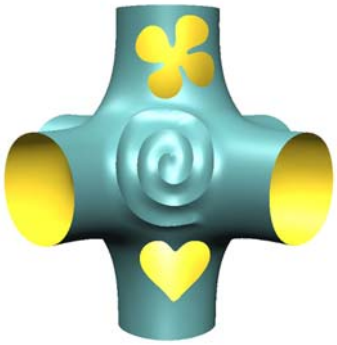
Sharp Features

Sharp features are important for the creation of non-trivial models

- engraving, embossing, trimming, …





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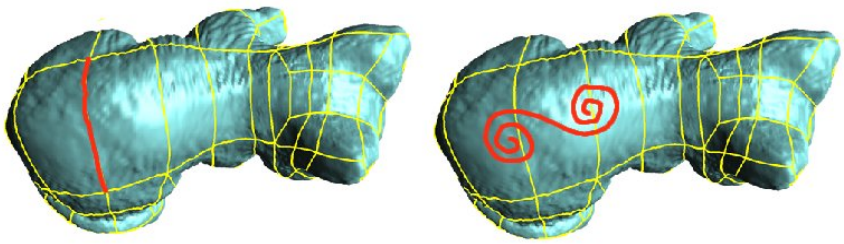
Problem

Features only at certain locations

- features restricted to seams between patches and iso-parameter lines

We want arbitrary placement without repatching!



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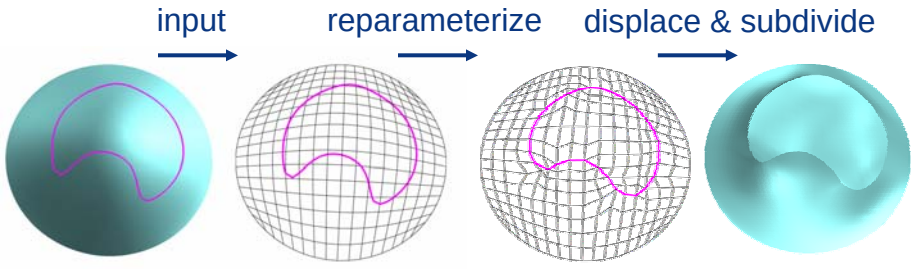
Method Overview

- Reparameterize surface
- Add feature profile
- Subdivide with special rules



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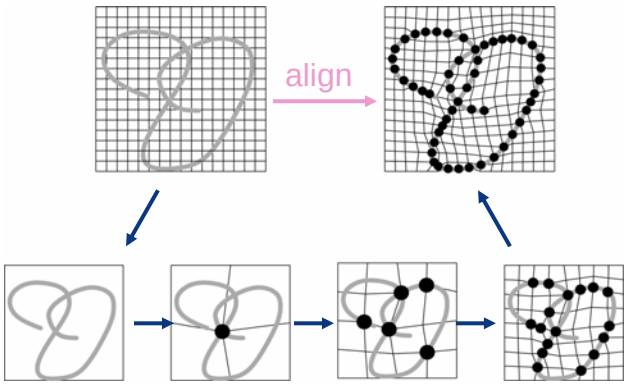
Reparameterization

Align feature with parameter lines

- snap vertices recursively to feature



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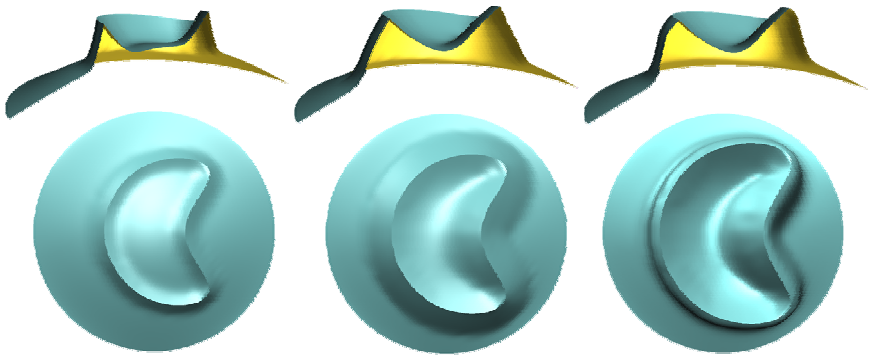
Creating Features

- mark features as creases
- apply offsets along features



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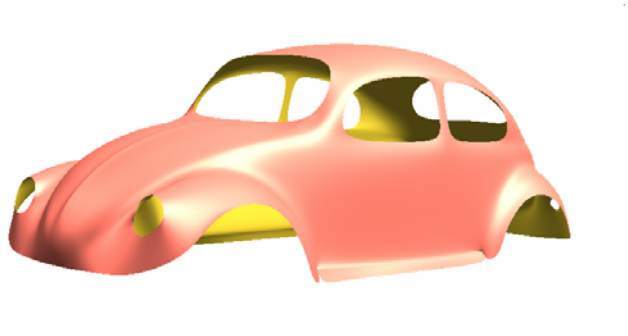
Demo



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Variational Design

With Remi Ronfard (INRIA)

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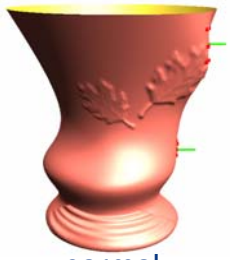
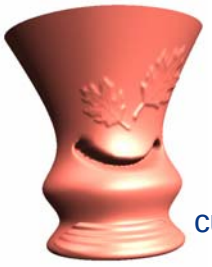
Free-Form Modeling

original

point constraints



normal constraints



curve constraints

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Method Overview

Energy:

- Define energy functional over the mesh
- Ensure optimization does not smooth out details

Locally parameterize mesh:

- fit quadratic interpolant at each control point
- construct divided difference operators

Deform mesh:

- impose constraints and propagate them across levels
- minimize global energy under constraints

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Energy Minimization

Avoid smoothing out details

- preserve multiresolution details

Minimize only the deformation energy

- i.e., in the presence of no constraints, the rest shape is the initial shape

$$E(P + \Delta P) = E(P) + E(\Delta P) + \sum_i f_i \Delta P_i + const$$

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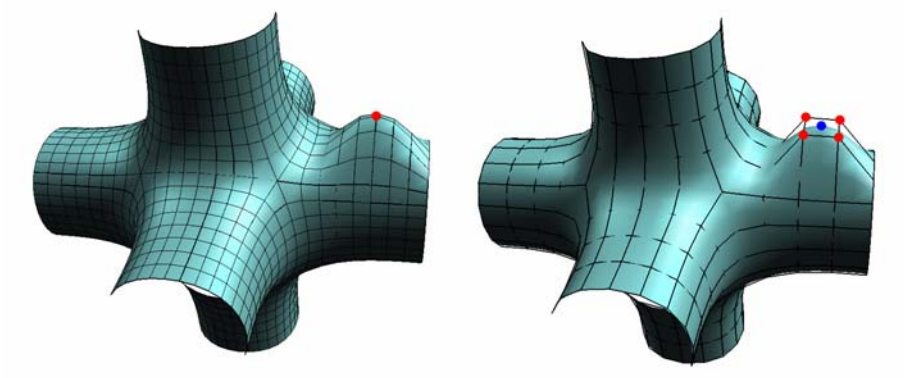
Multiresolution Constraints

Linear constraints are propagated across subdivision levels



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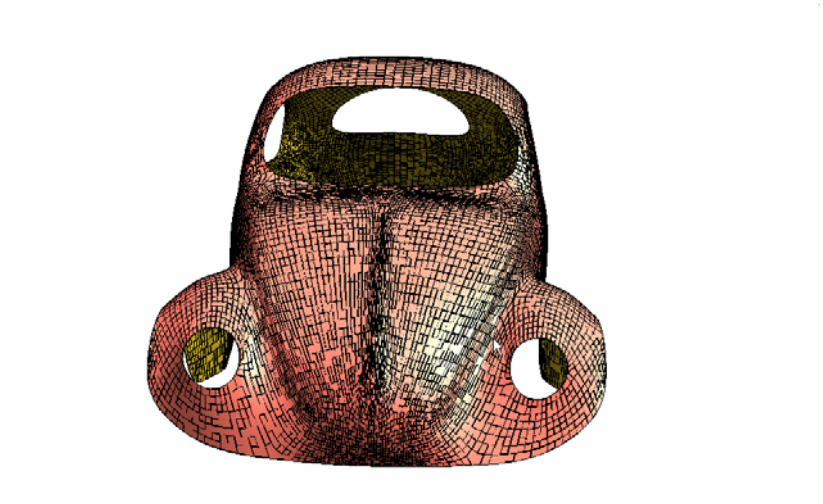
Demo



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Semi-Regular Remeshing

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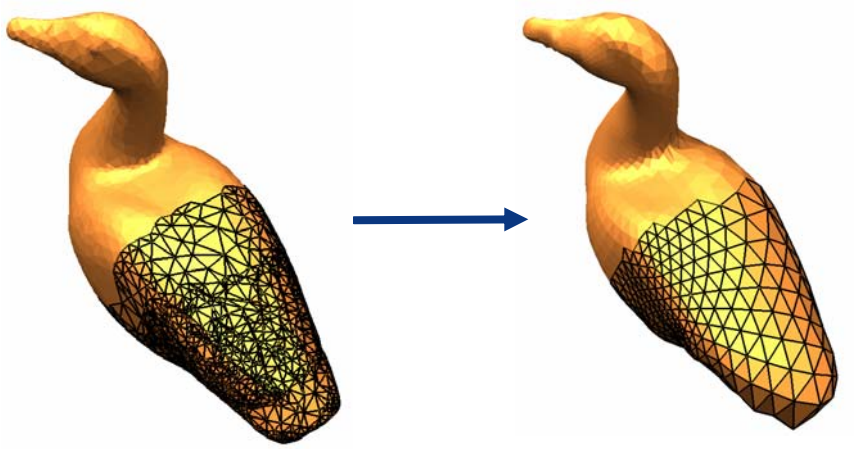
Remeshing: Loop



Irregular-connectivity mesh

Semi-regular multiresolution representation

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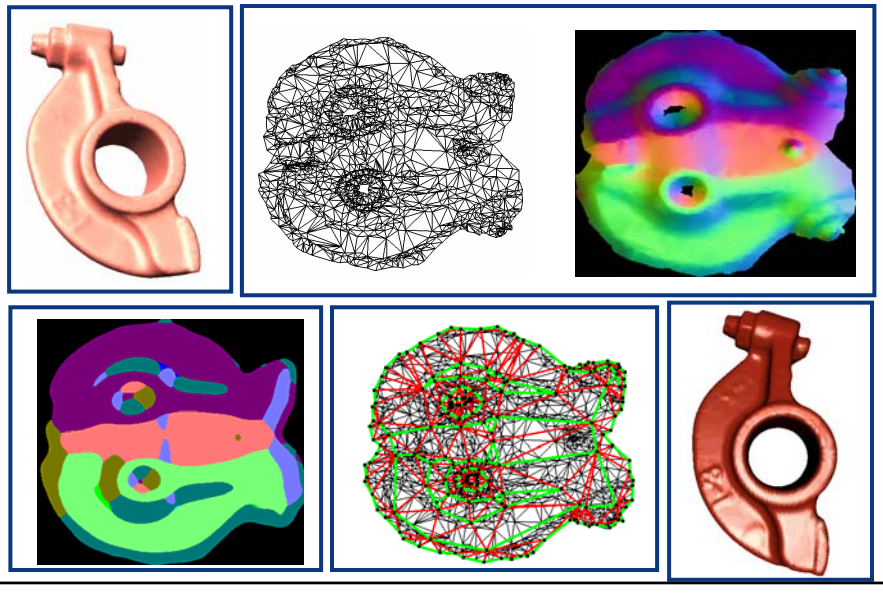
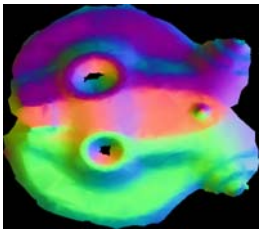
Algorithm Overview



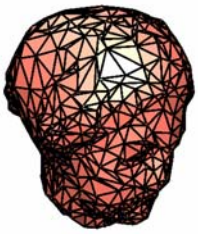
F# 3,060



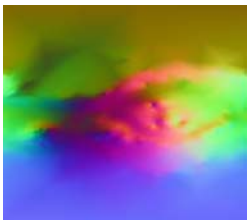
Conformal
(Desbrun)

F# 236

5 levels



F# 1,718



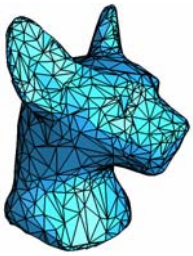
Spherical
(Brechbühler)

F# 78

5 levels

Results

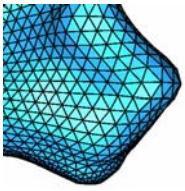
F# 14,569

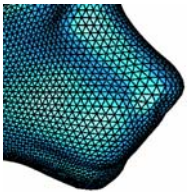


F# 1,705

F# 142

4 levels





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THE END

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