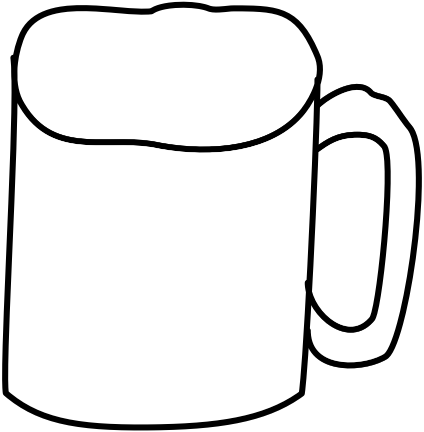
On Sketches for Modeling

Emilio Ashton Vital Brazil

Advisor: Luiz Henrique de Figueiredo
Co-advisor: Mario Costa Sousa

February 22, 2011

Why Sketch

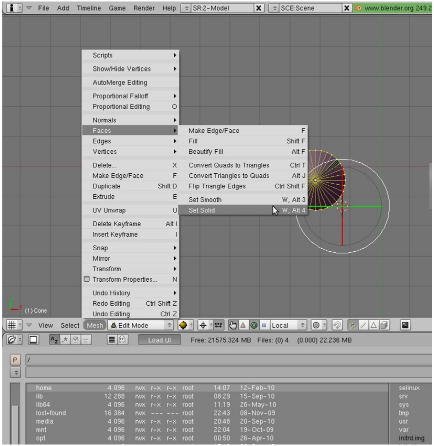


Why Sketch

Why Sketch

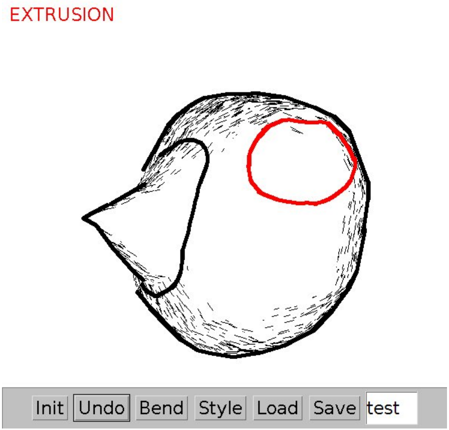
Illustration: **Andrew Loomis**, 1943

Sketch-Modeling × WIMP



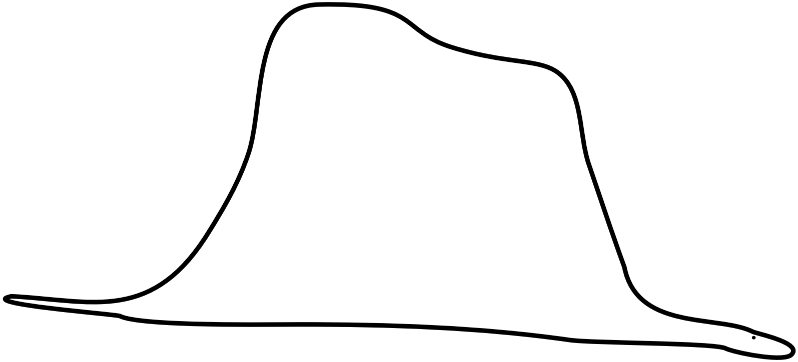
Blender System

Sketch-Modeling × WIMP

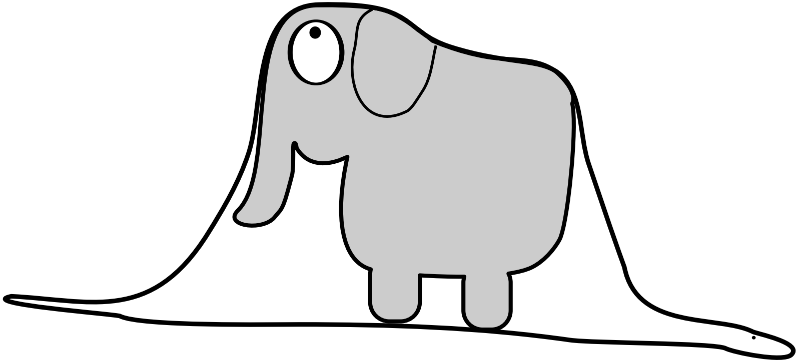


Teddy System,**Igarashi et al.**, 1999

Problem!!!



Problem!!!

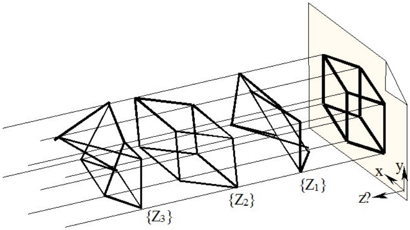


Problem!!!

"My drawing was not a picture of a hat. It was a picture of a boa constrictor digesting an elephant. But since the grown-ups were not able to understand it ... They always need to have things explained."

The Little Prince; **de Saint-Exupéry, A.**, 2000

Problem!!!

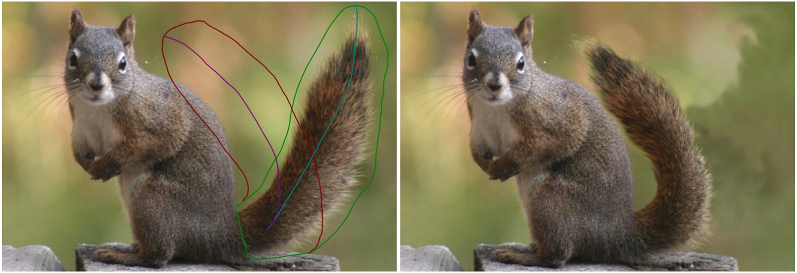


Marsy and Lipson, 2005

How

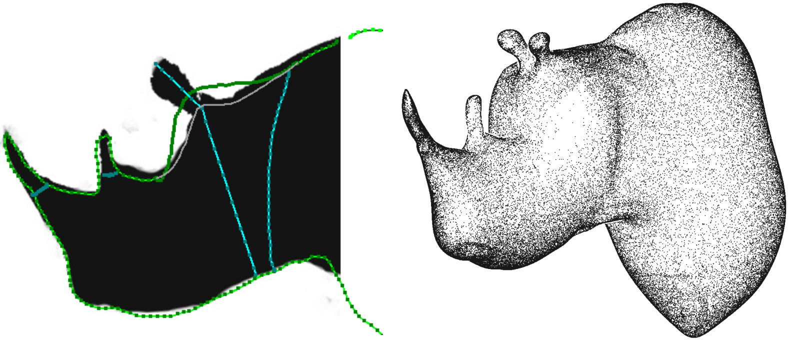
- The mathematical representation of the model plays a central role in sketch-based modeling systems.
- There are common requirements on model representation in different SBM applications.

Modeling



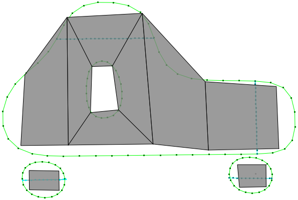
Graphical Models,**Pereira et al.**, 2011

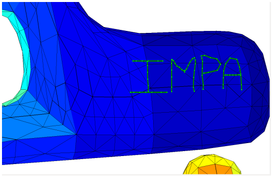
Modeling

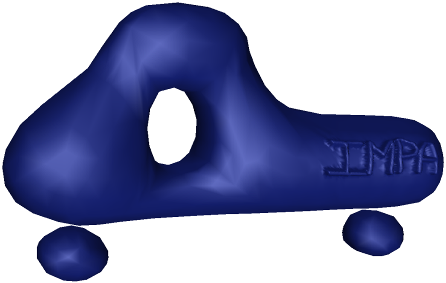


SBIM'10,**Vital Brazil et al.**, 2010; *NPAR'10*,**Vital Brazil et al.**, 2010; *Computer & Graphics*,**Vital Brazil et al.**, 2011

Modeling



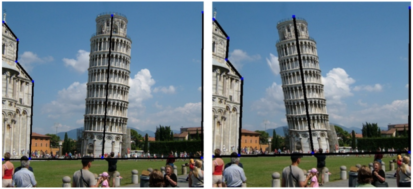




To appear ...

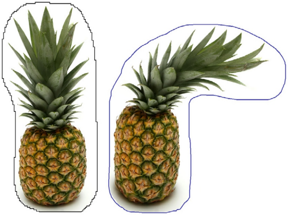
Image Warping: Points and lines

Igarashi et al., 2005



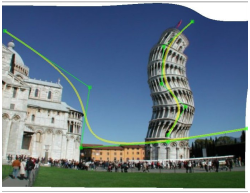
Schaefer et al., 2006

Image Warping: Sketches



Eitz et al., 2007

Fang and Hart, 2007



Weng et al., 2008

Image Warping

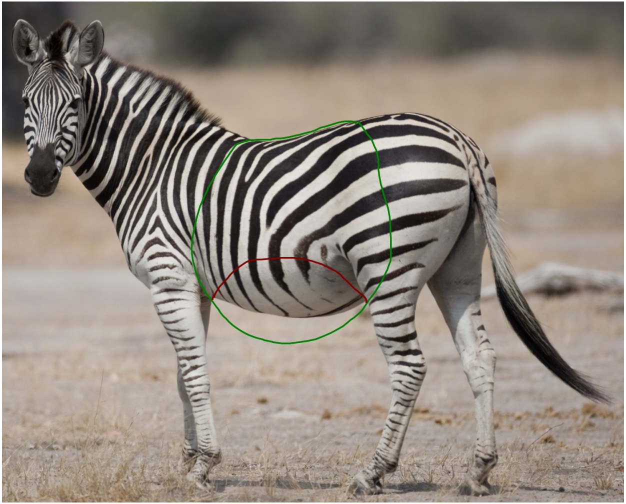
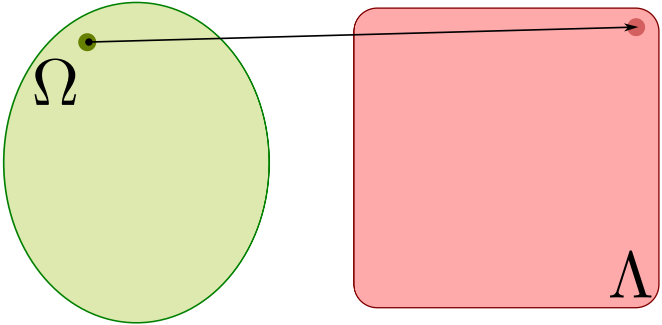


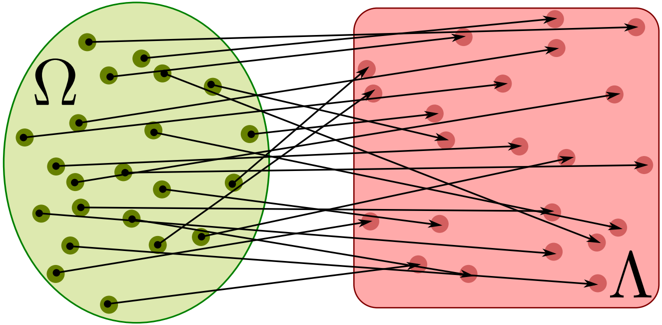
Image Warping

Image Warping

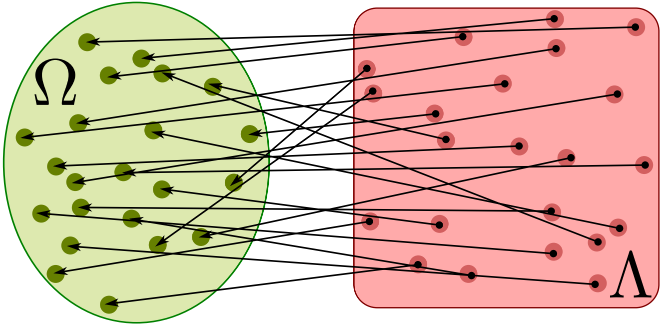
Warping Field



Warping Field



Warping Field



Warping Field

$$\mathsf{W}(\mathsf{x}) = \mathsf{x} + \mathsf{F}(\mathsf{x})$$

$$\mathsf{F} : \mathbb{R}^2 \to \mathbb{R}^2$$

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$$\mathsf{F} \in C^1$$

$$\mathbf{F} \notin C^1$$

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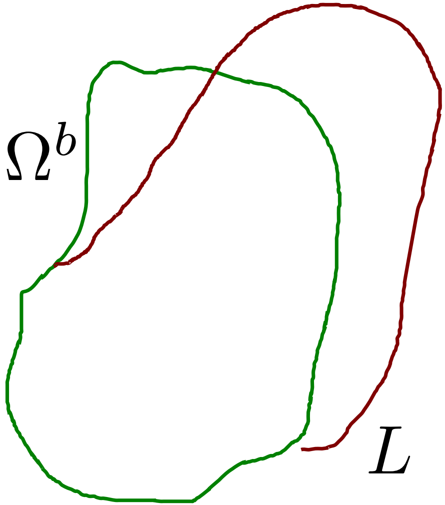
The Regions



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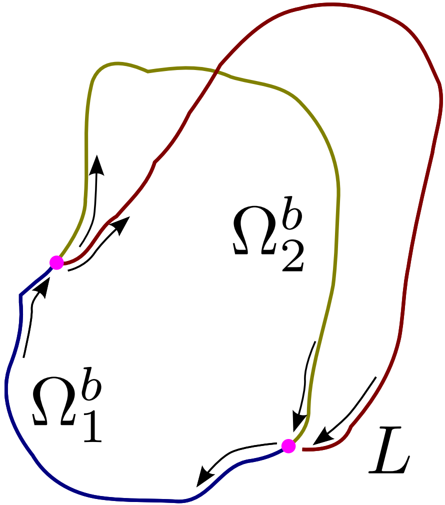
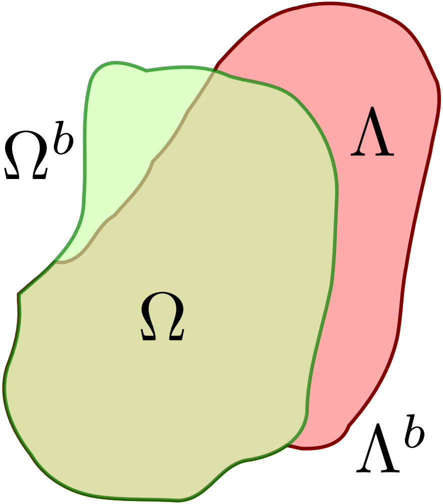
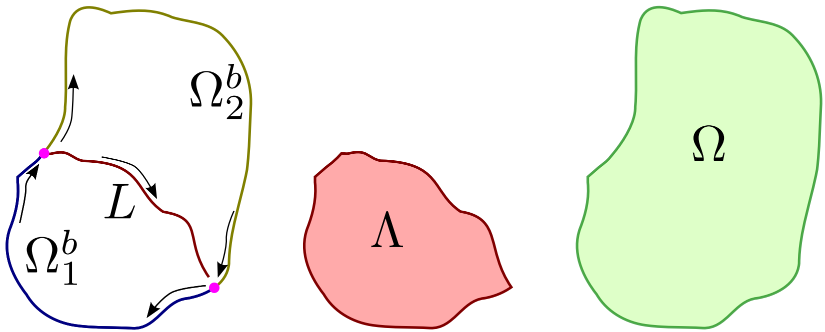


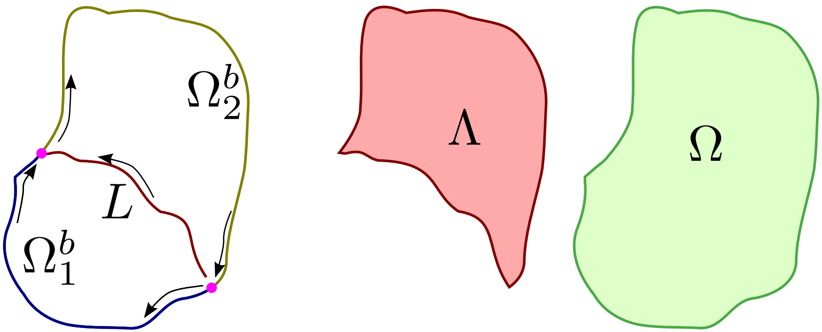
The Regions



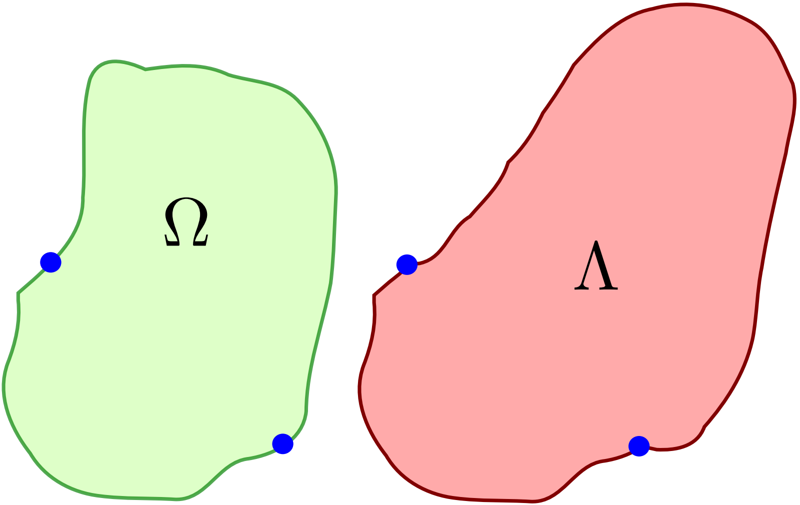
The Regions

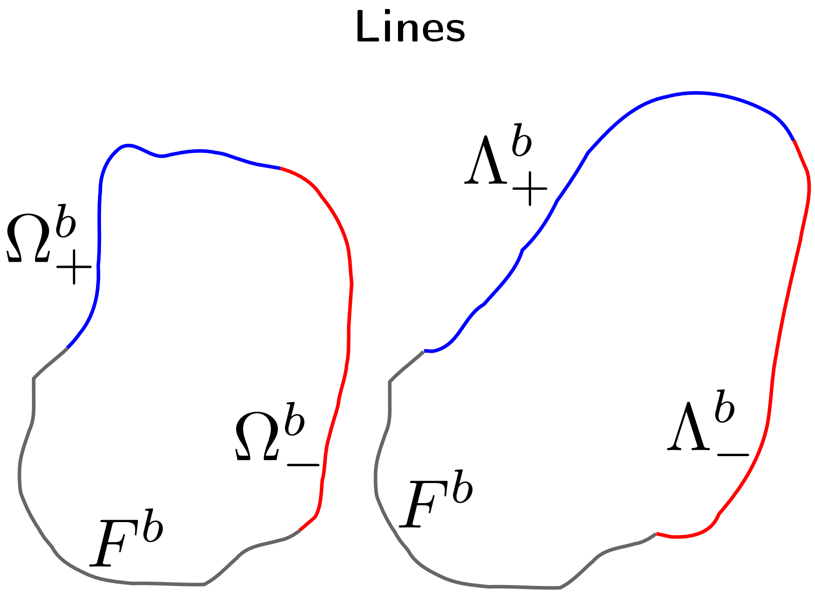


The Regions

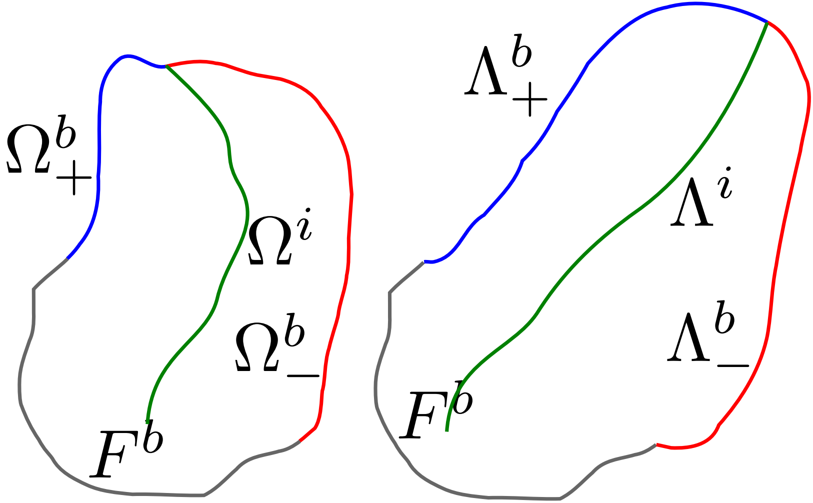


Lines

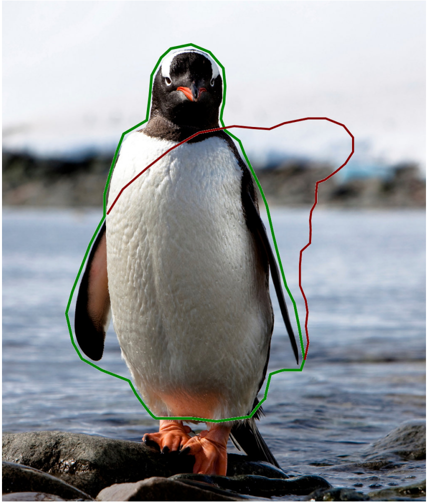



Lines
Ω^b_+
Ω^b_-
F^b
Λ^b_+
Λ^b_-
F^b

Lines



Lines



Lines

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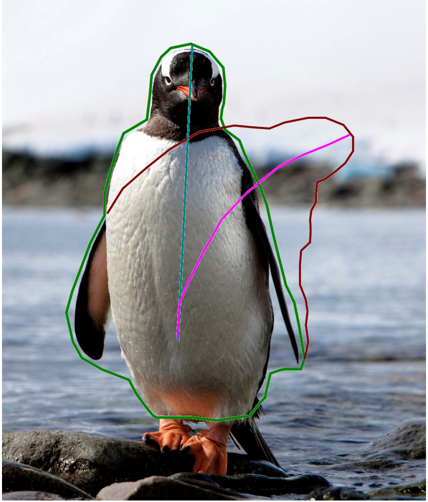
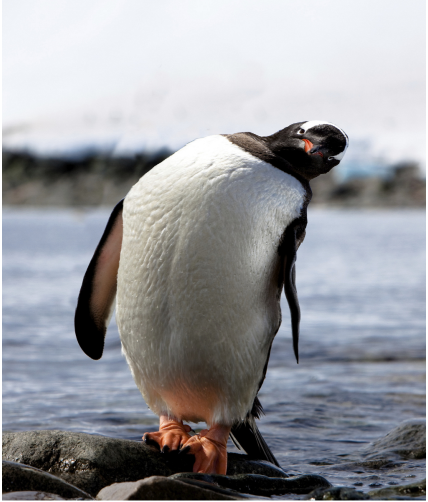
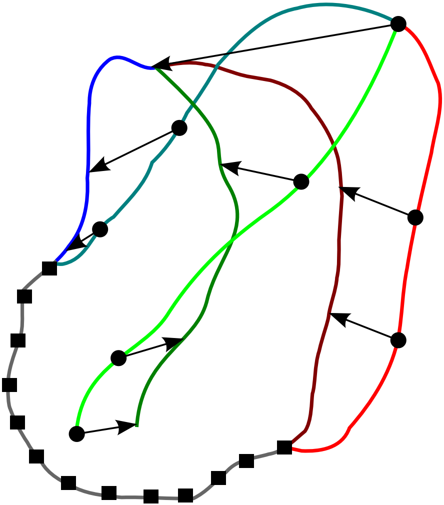


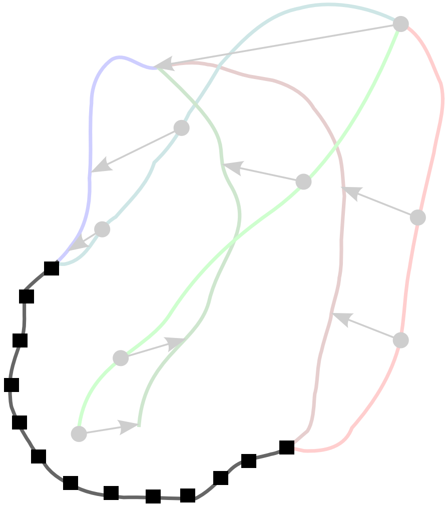
Lines



Samples



Samples



Constraints

$$\mathbf{F} : \mathbb{R}^2 \to \mathbb{R}^2$$

such that

$$\mathbf{F}(\boldsymbol{\lambda}^j) = \mathbf{c}^j,$$

$$\mathbf{F}(\mathbf{x}^k) = \mathbf{0},$$

and

$$D\mathbf{F}(\mathbf{x}^k) = \mathbf{0},$$

Interpolant Field – HBRBF

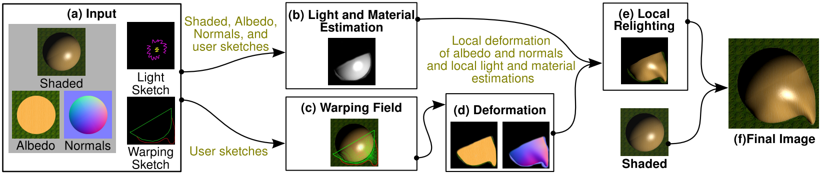
$$F_\ell(\mathsf{x}) = \sum_k \Big\{ \alpha_k \psi(\mathsf{x} - \mathsf{x}^k) - \langle \boldsymbol{\beta}^k, \nabla\psi(\mathsf{x} - \mathsf{x}^k) \rangle \Big\} + \sum_j \gamma_j \psi(\mathsf{x} - \boldsymbol{\lambda}^j) + \langle \mathsf{a}, \mathsf{x} \rangle + b; \quad \ell = 1, 2$$

$$\sum_k \Big\{ \alpha_k \mathsf{x}^k + \boldsymbol{\beta}^k \Big\} + \sum_j \gamma_j \boldsymbol{\lambda}^j = \mathbf{0}$$

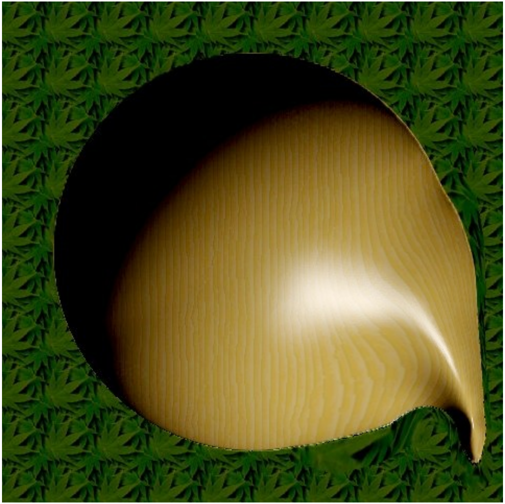
$$\sum_k \alpha_k + \sum_j \gamma_j = 0.$$

Macêdo et al., 2011

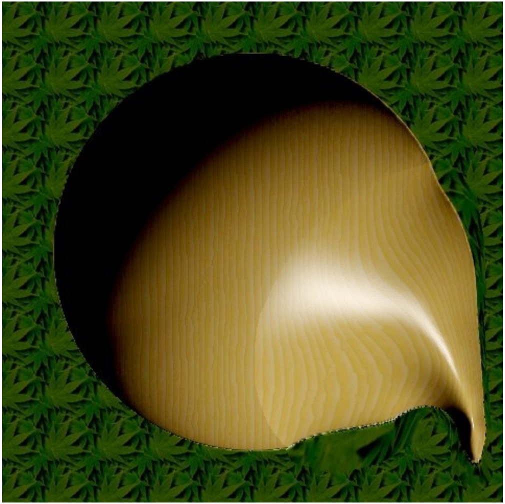
Application in RGBN Images



Results



Results



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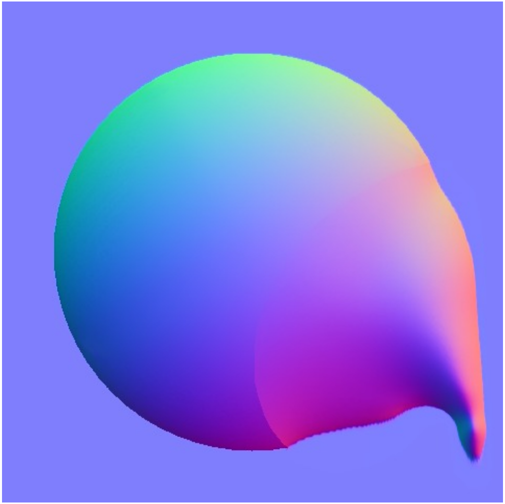

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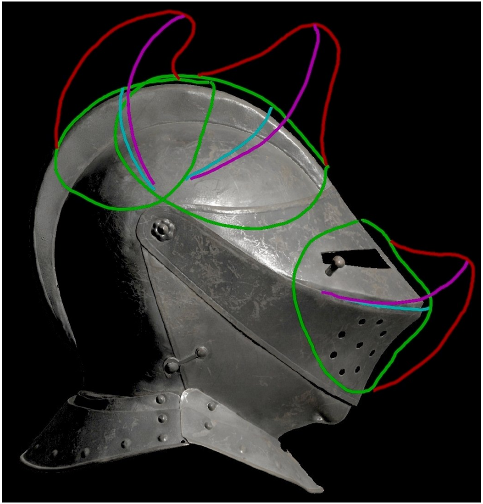
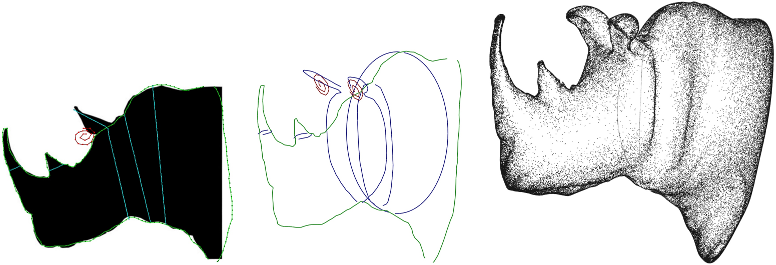


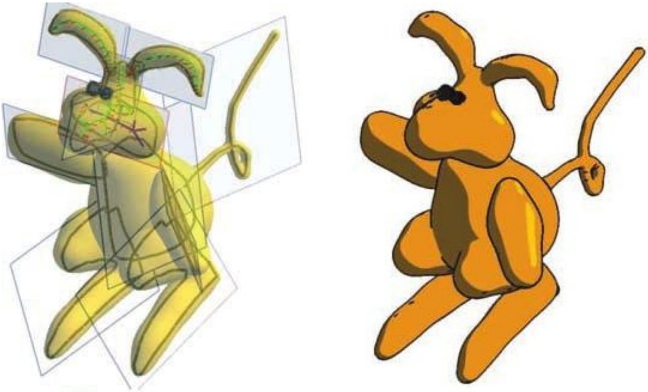
Results

Results

Sketch Based Implicit Modeling

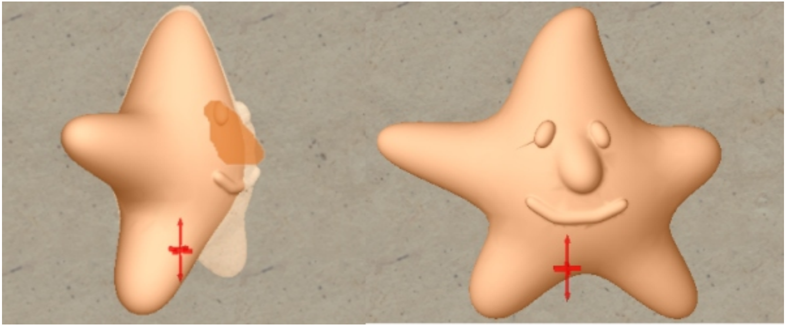


Implicit Modeling - Related Work



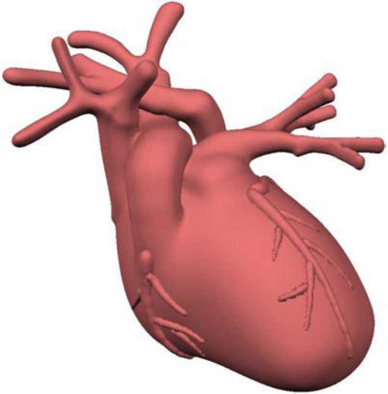
convolution implicit surfaces: **Tai et al.**, 2004

Implicit Modeling - Related Work



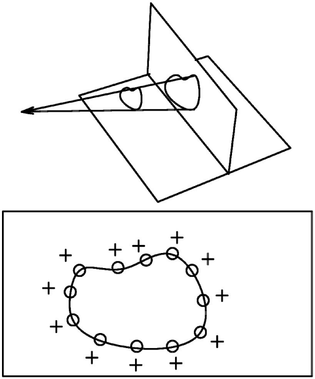
convolution implicit surfaces: **Bernhardt et al.**, 2008

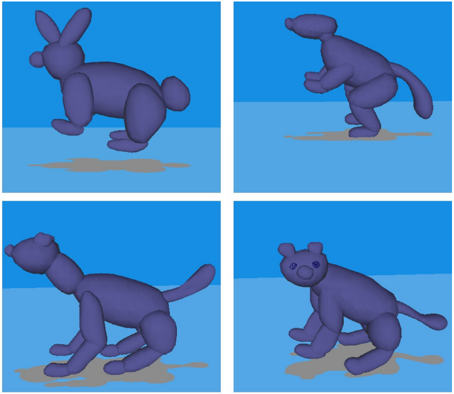
Implicit Modeling - Related Work



hierarchical implicit modeling: **Schmidt et al.**, 2005

Implicit Modeling - Related Work





Variational Implicit Surfaces: **Karpenko et al.**, 2002

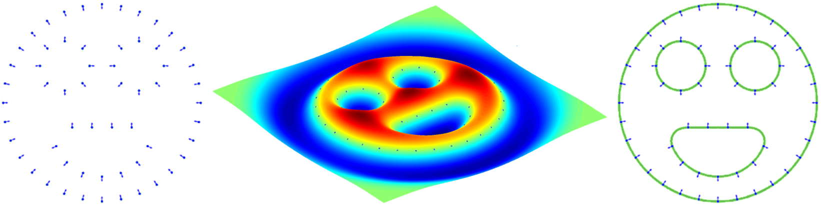
Variational HRBF Implicits

Representation

Given $(\mathbf{x}^1, \mathbf{n}^1), \ldots, (\mathbf{x}^N, \mathbf{n}^N) \in \mathbb{R}^3 \times \mathbb{S}^2$

Find $f : \mathbb{R}^3 \to \mathbb{R}$ such that $f(\mathbf{x}^i) = 0$ and $\nabla f(\mathbf{x}^i) = \mathbf{n}^i$

VHRBF Implicits interpolant:



Macêdo et al., 2011

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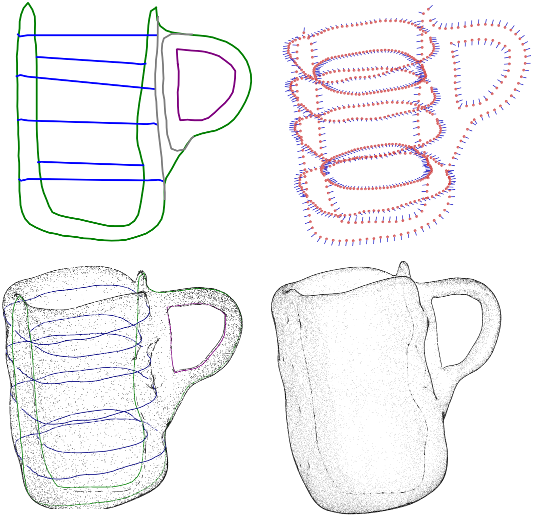
VHRBF Implicits interpolant:

$$f(\mathsf{x}) = \sum_{j=1}^{N} \left\{ \alpha_j \|\mathsf{x} - \mathsf{x}^j\|^3 - 3\langle \beta^j, \mathsf{x} - \mathsf{x}^j \rangle \|\mathsf{x} - \mathsf{x}^j\| \right\} + \langle \mathbf{a}, \mathsf{x} \rangle + b$$

$4N + 4$ unknowns

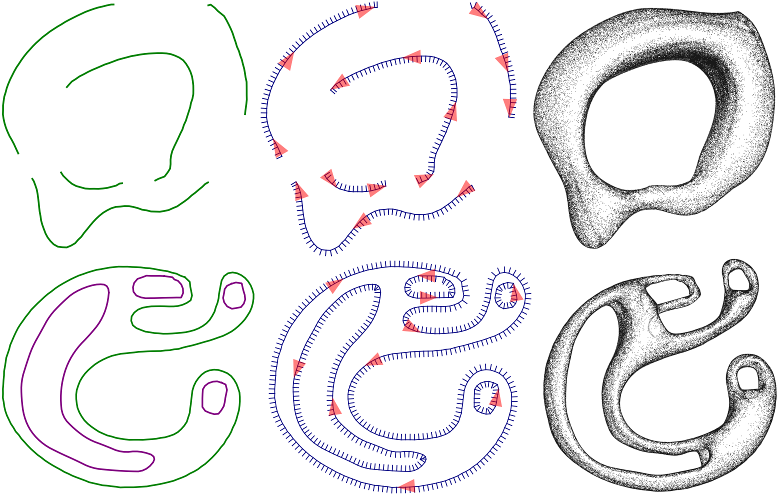
Sketching Variational HRBF Implicits

Pipeline



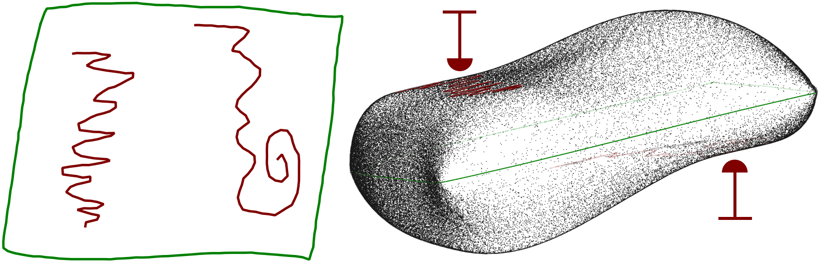
Sketching Variational HRBF Implicits

Contouring operators



Sketching Variational HRBF Implicits

Inflation operators: Kneading



Sketching Variational HRBF Implicits

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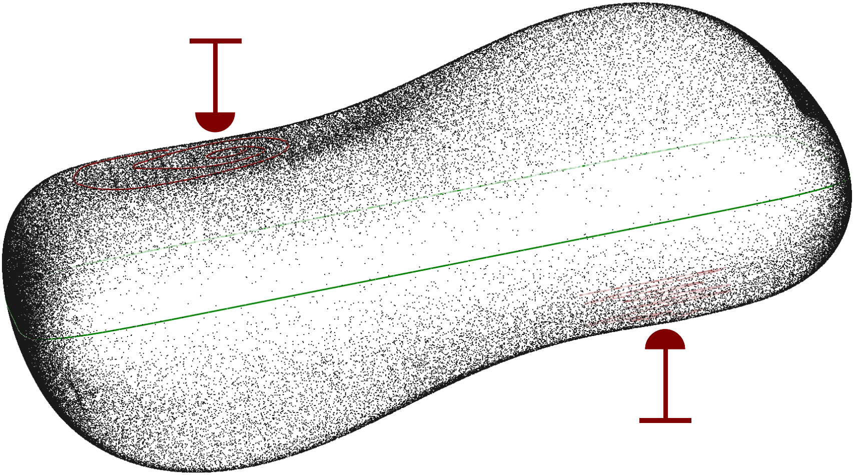
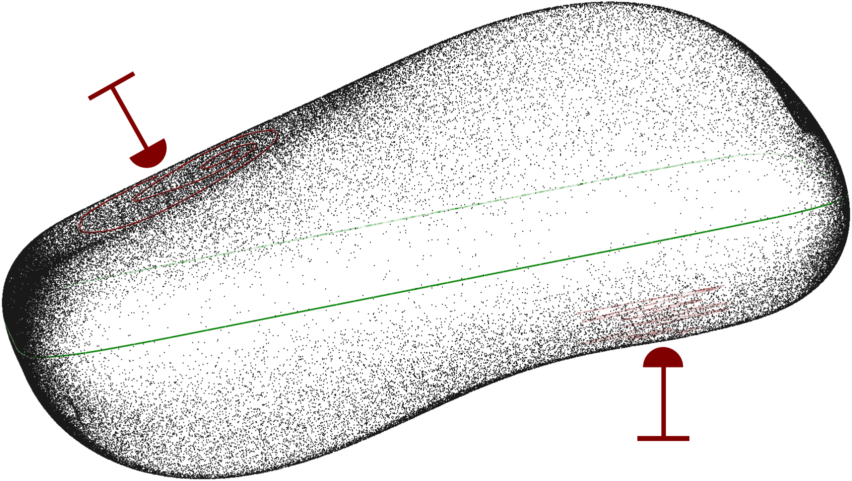


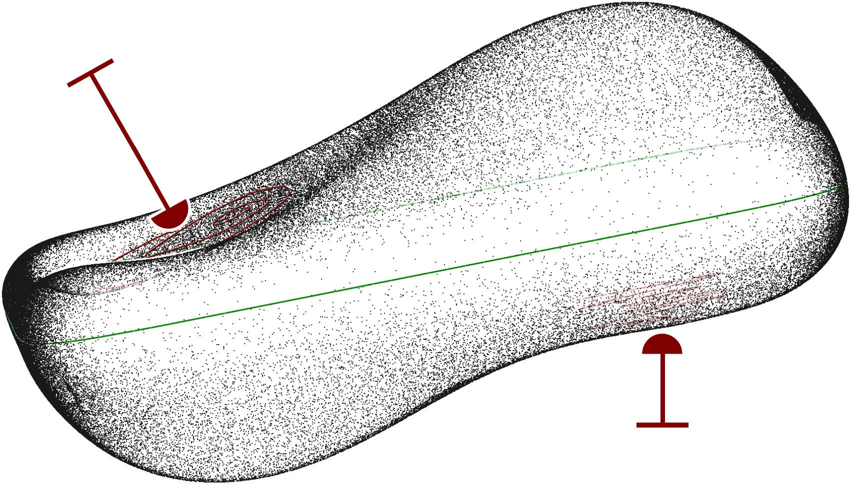
Sketching Variational HRBF Implicits

Inflation operators: Kneading



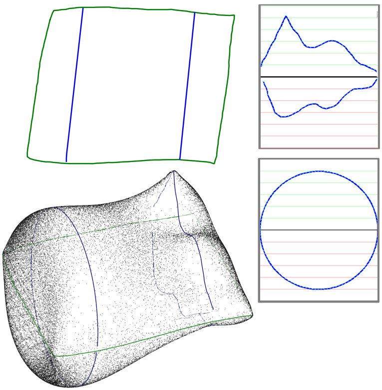
Sketching Variational HRBF Implicits

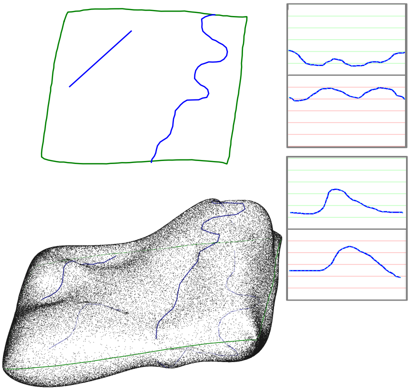
Inflation operators: Kneading



Sketching Variational HRBF Implicits

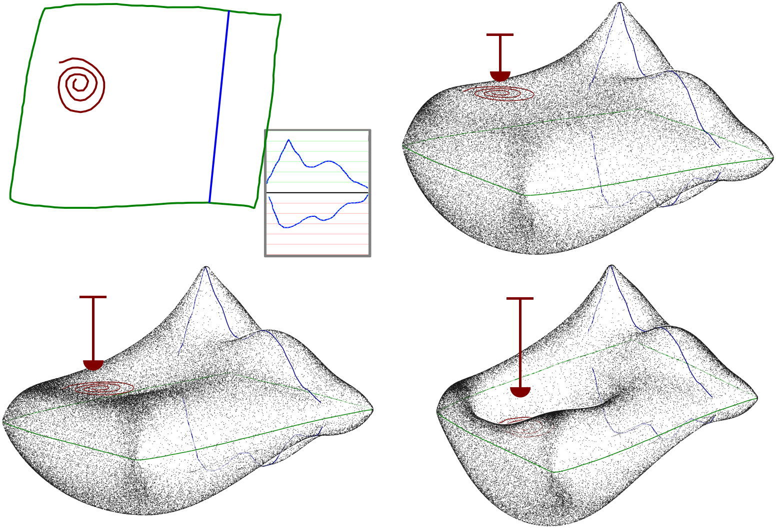
Inflation operators: Cross-editing





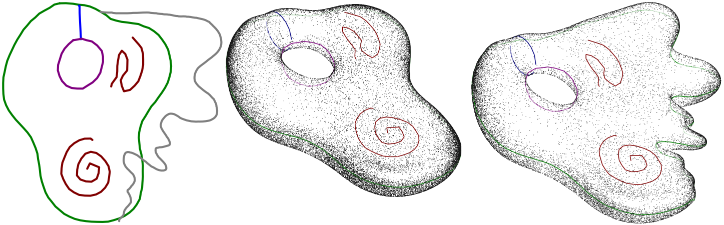
Sketching Variational HRBF Implicits

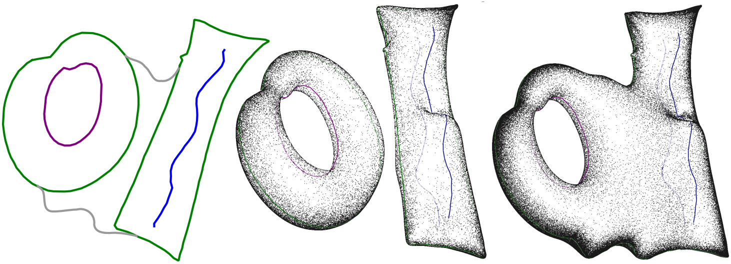
Inflation operators: Kneading and Cross-editing



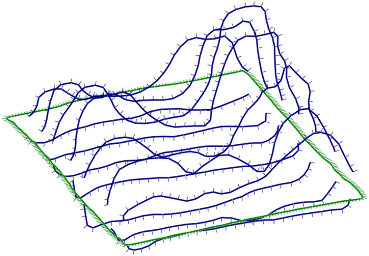
Sketching Variational HRBF Implicits

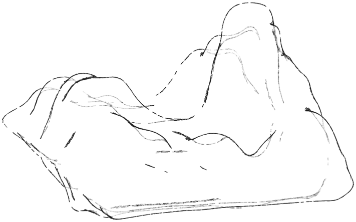
Oversketching operators

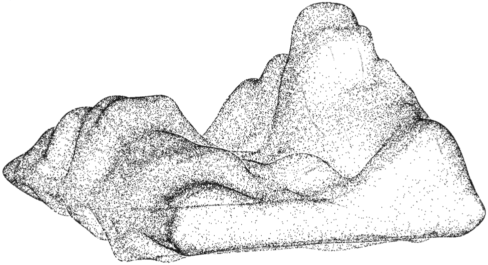




Results







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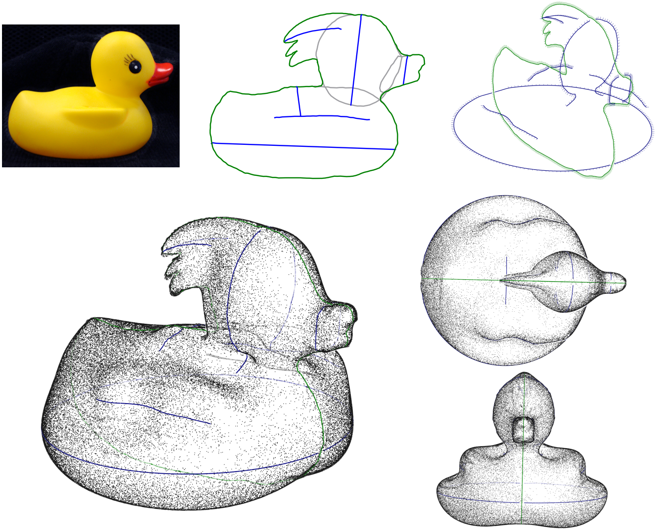


Introduction

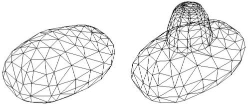
Warping Fields

Sketching Implicit Surfaces

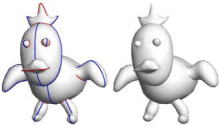
Surface Representation for SBIM

Final Remarks

Surface Representations for SBSM

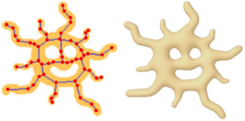


Igarashi et al., 1999

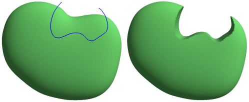


Nealen et al., 2007

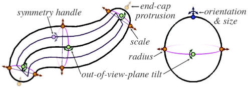
Karpenko et al., 2002



Bernhardt et al., 2008



Schmidt et al., 2005



Gingold et al., 2008

Surface Representations for SBSM

- Flexibility
- Local x Global
- Save and Editing stages
- Templates

A Surface Representations for SBSM

$$\widetilde{\mathcal{S}} = \mathcal{S} \oplus D(\mathcal{S})$$

$$\mathcal{S} \subset \mathbb{R}^d \times \mathcal{P} \qquad D : \mathcal{S} \to \mathbb{R}^d \times \mathcal{P}$$

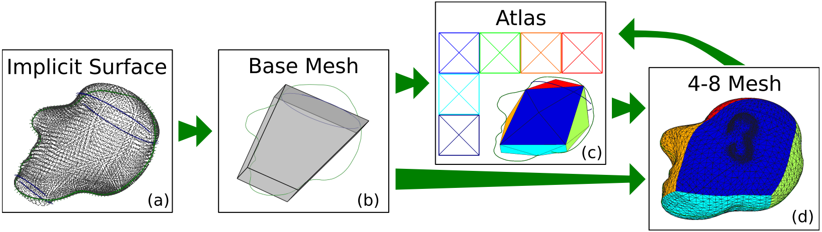
$$D = \Phi \circ \Psi$$

$$\Psi\colon \mathcal{S} \to \mathcal{A} \times \mathcal{P}'$$

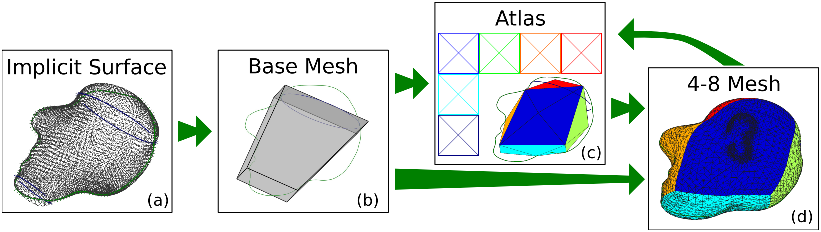
$$\Phi\colon \mathcal{A} \times \mathcal{P}' \to \mathbb{R}^d \times \mathcal{P}$$

$$\widetilde{\mathcal{S}} = \mathcal{S} \oplus_1 D_1 \oplus_2 D_2 \cdots \oplus_n D_n$$

Pipeline



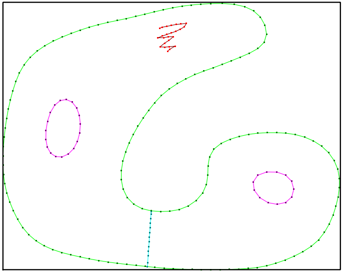
Pipeline

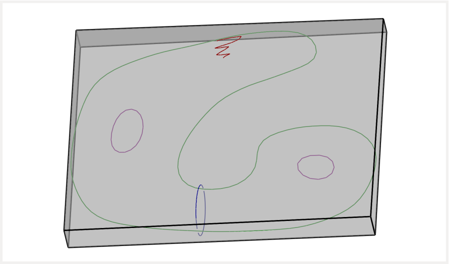


$$\widetilde{\mathcal{S}} = \mathcal{S} + D(\mathcal{S})$$

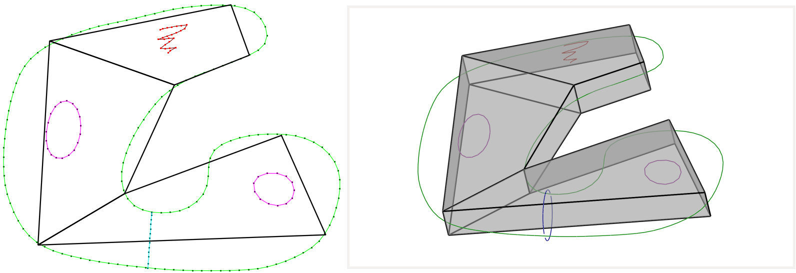
$$\tilde{p} = p + h_p N_p$$

Base Mesh





Base Mesh



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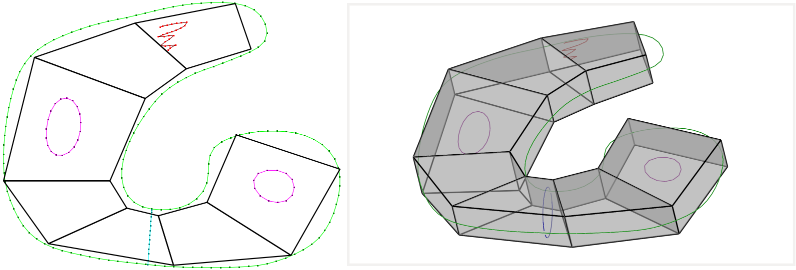
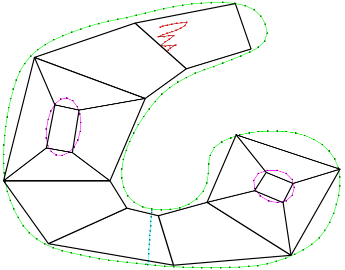
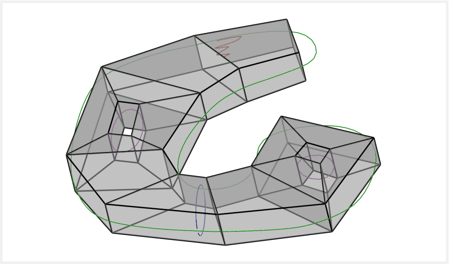
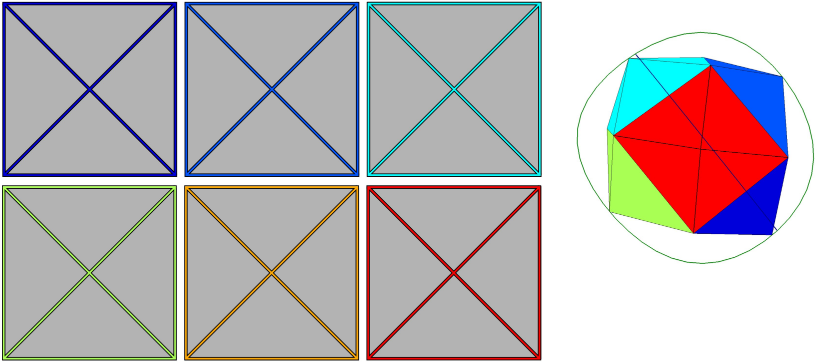


Base Mesh

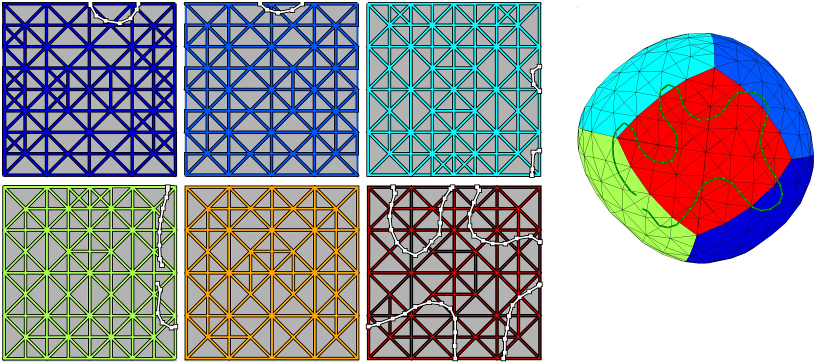




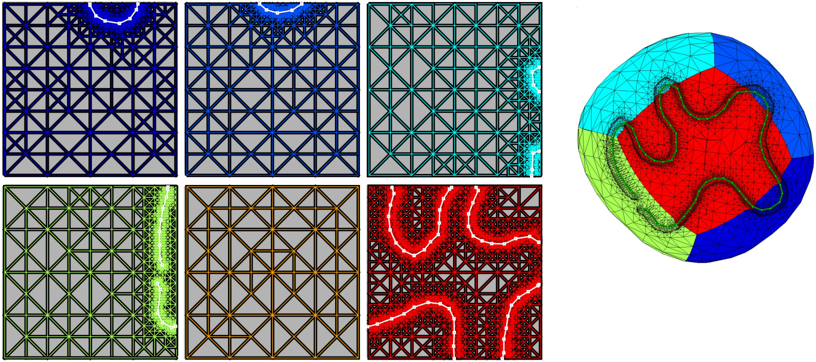
Atlas



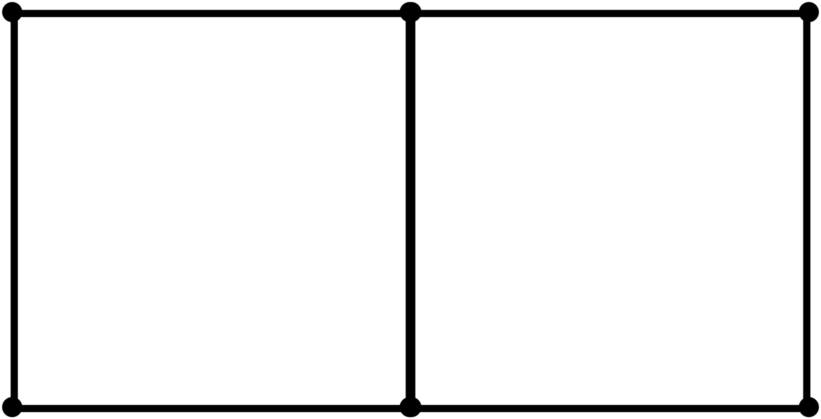
Atlas



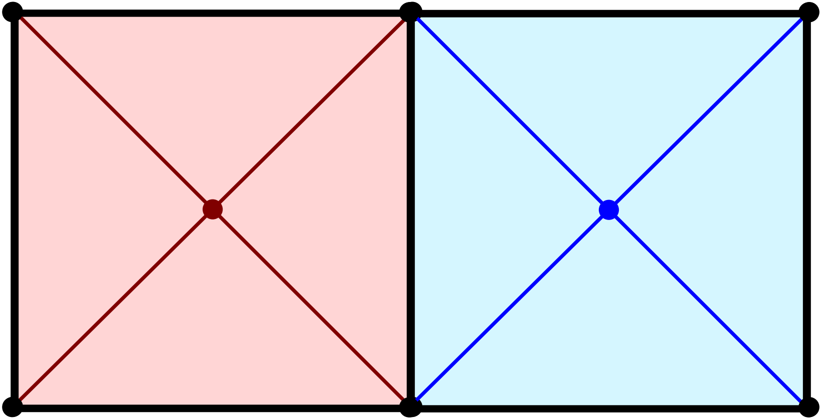
Atlas



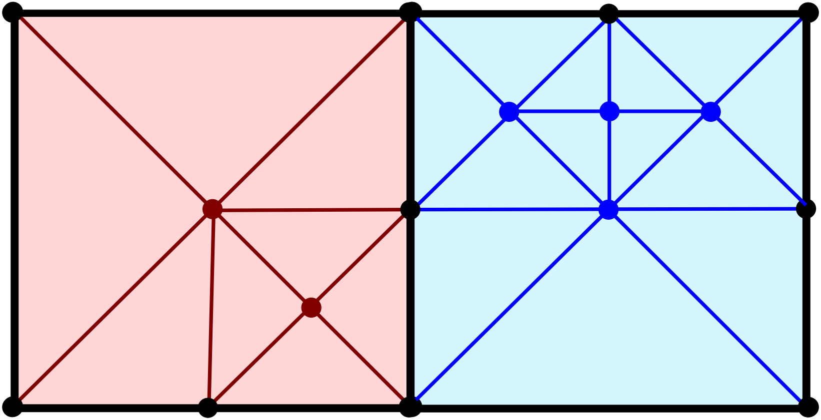
Vertex Atlas



Vertex Atlas

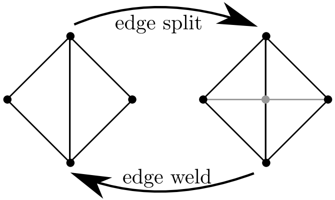


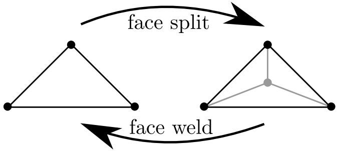
Vertex Atlas



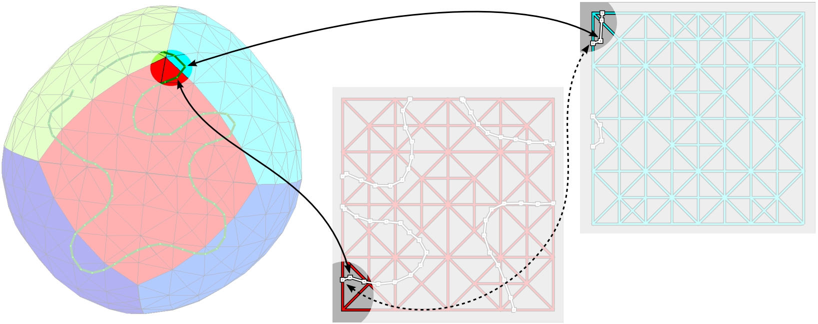
Atlas

Stellar Operators

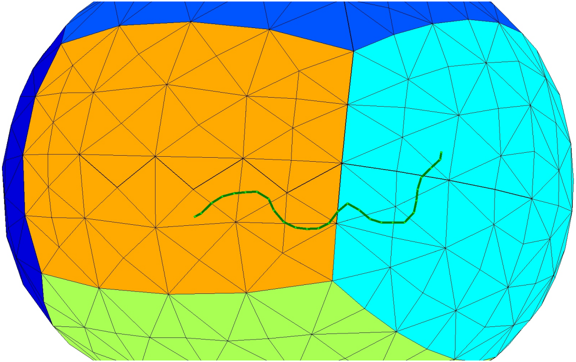




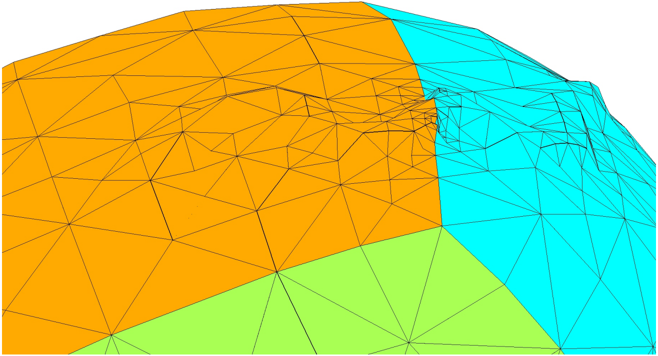
Atlas



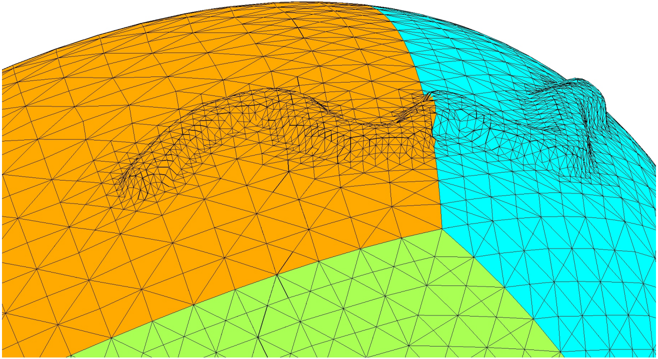
4-8 Mesh



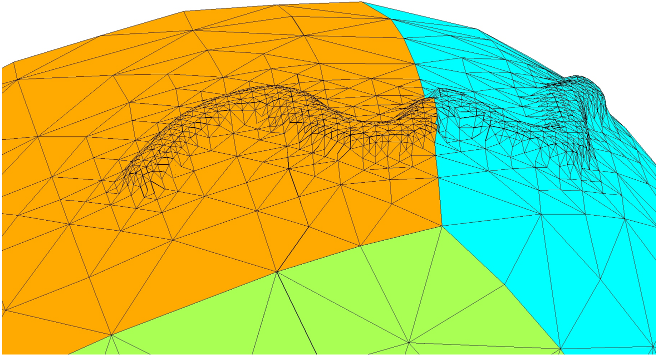
4-8 Mesh



4-8 Mesh



4-8 Mesh



4-8 Mesh Local Error

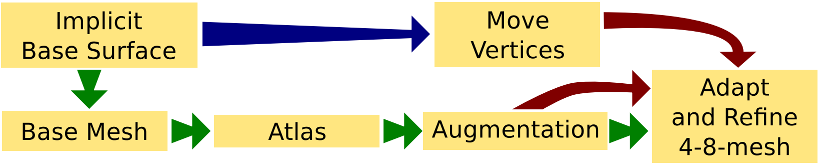
$$E(p) = \eta(D_g(p))$$

$$\eta : \mathbb{R}^d \to \mathbb{R}_+$$

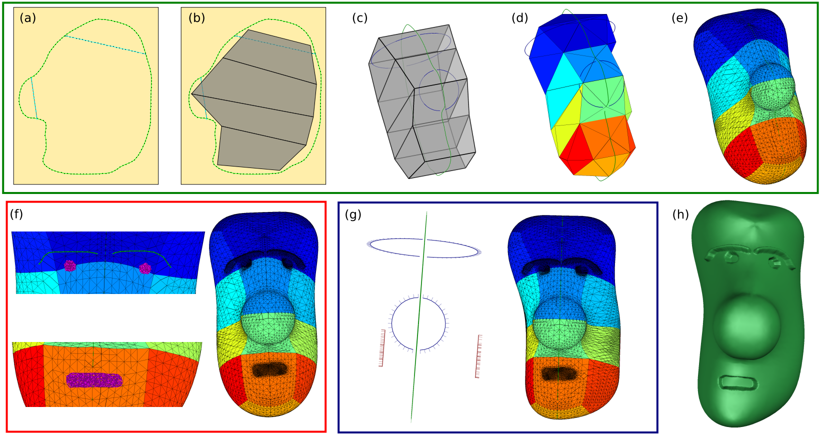
$$\Delta(p) = d_{\widetilde{S}}(p)E(p)$$

$$E(p) = \max\{2|\nabla h_p|, 1\}$$

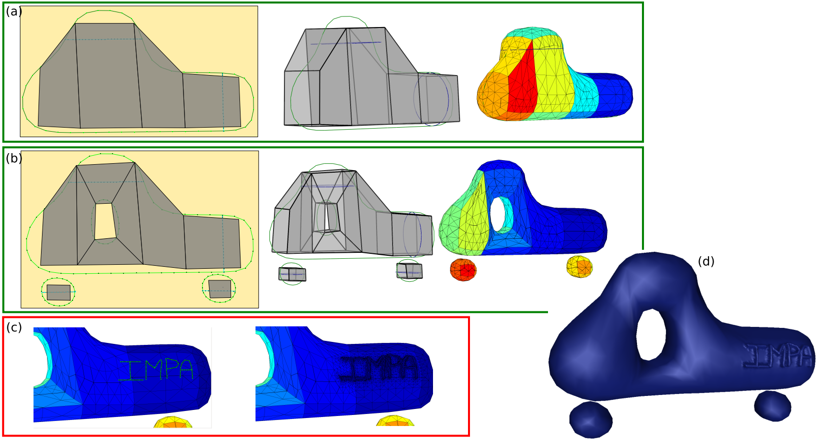
Work-flow


Implicit
Base Surface
Move
Vertices
Adapt
and Refine
4-8-mesh
Base Mesh
Atlas
Augmentation

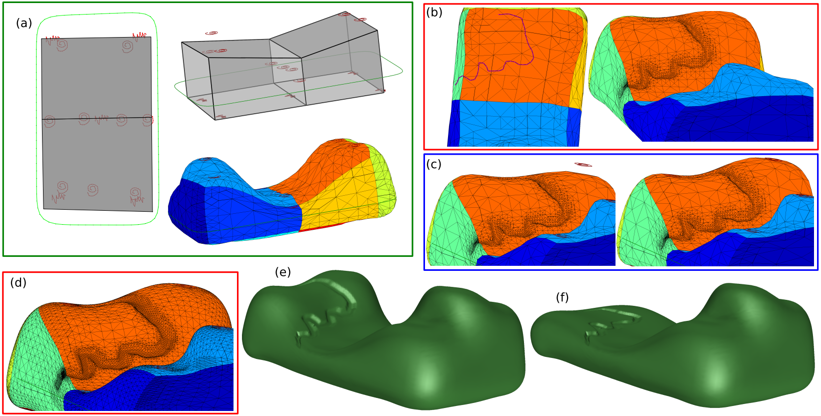
Results



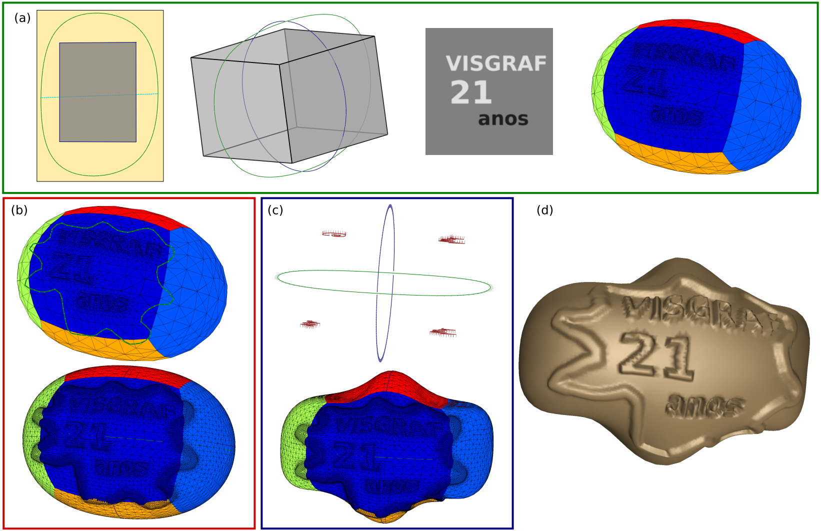
Results



Results



Results



Final Remarks

- Representations;
- Specific domains;
- Research avenues;

Thanks!!!

Sketch as Input