

Traitement, **Analyse** et Edition de Formes 3D Numérisées

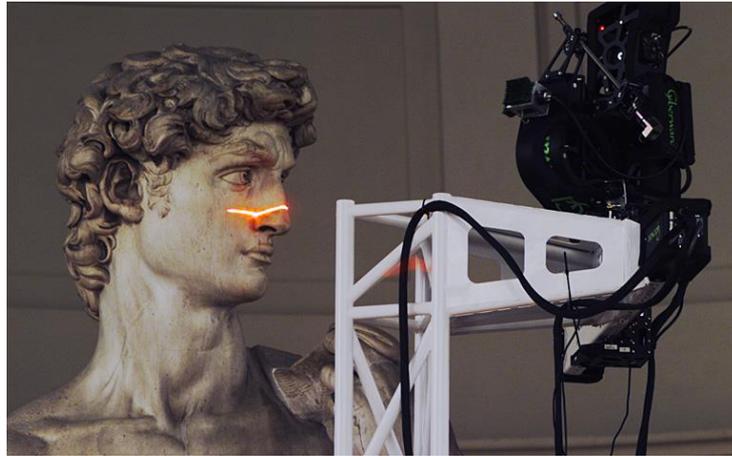
Tamy Boubekur



NUMÉRISATION 3D

Démocratisation de la capture 3D

Années 90



Michelangelo Project, Stanford

Aujourd'hui



Structure Sensor



Google Tango Project



Microsoft Kinect



[Tanskanen 2013]

Stéréovision mobile

Données massives

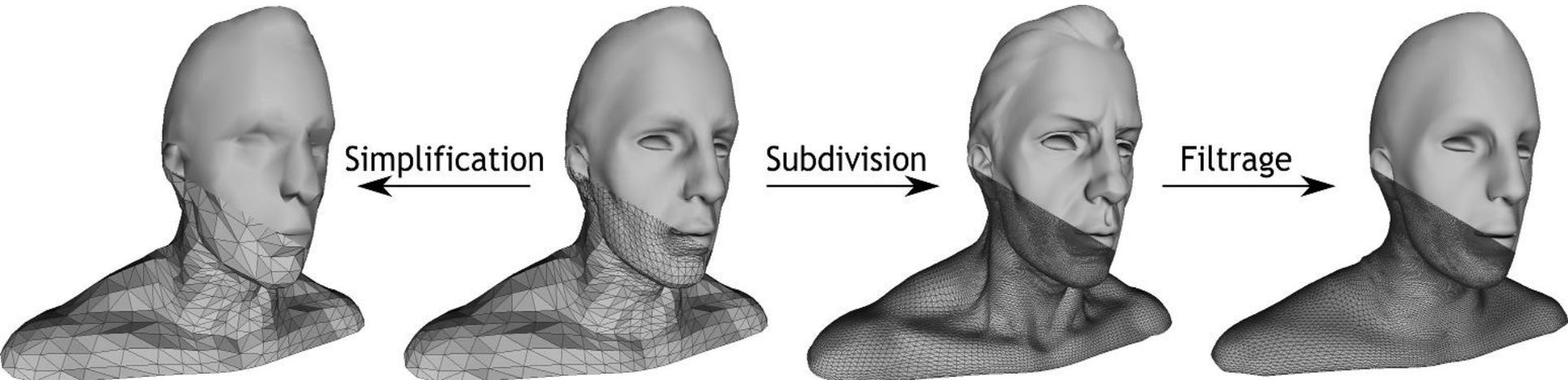


full speed

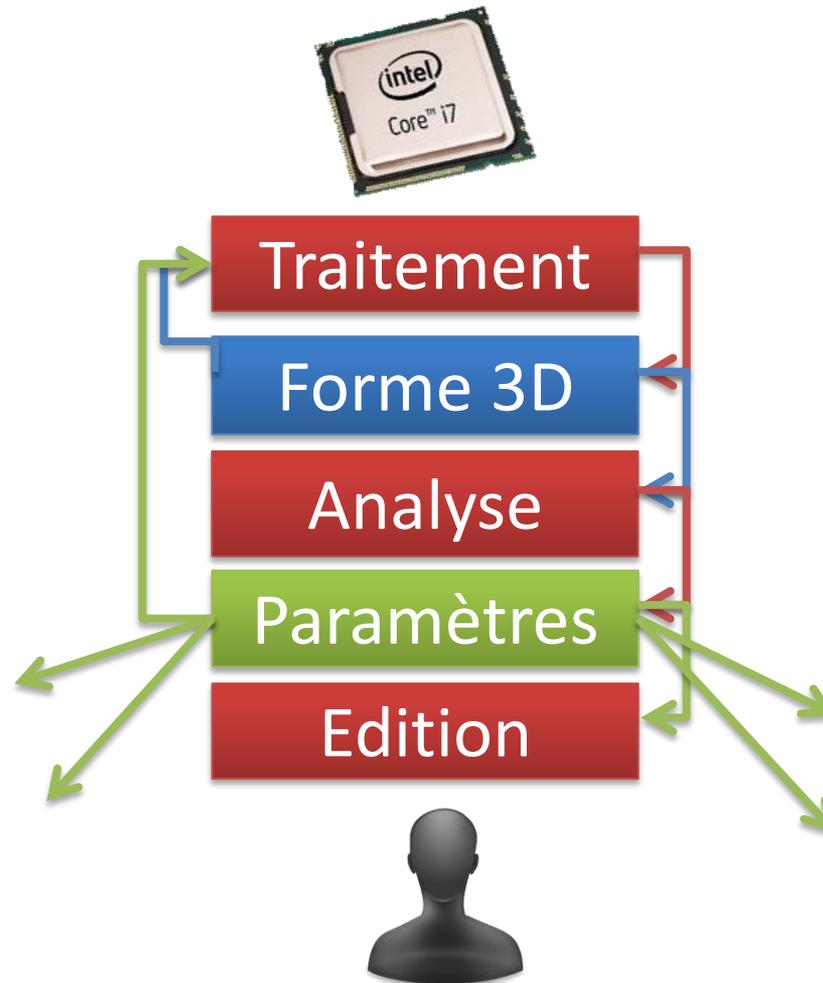
VIDEO

Données 3D+t [Bradley, Popa, Sheffer, Heidrich, Boubekeur 2008]

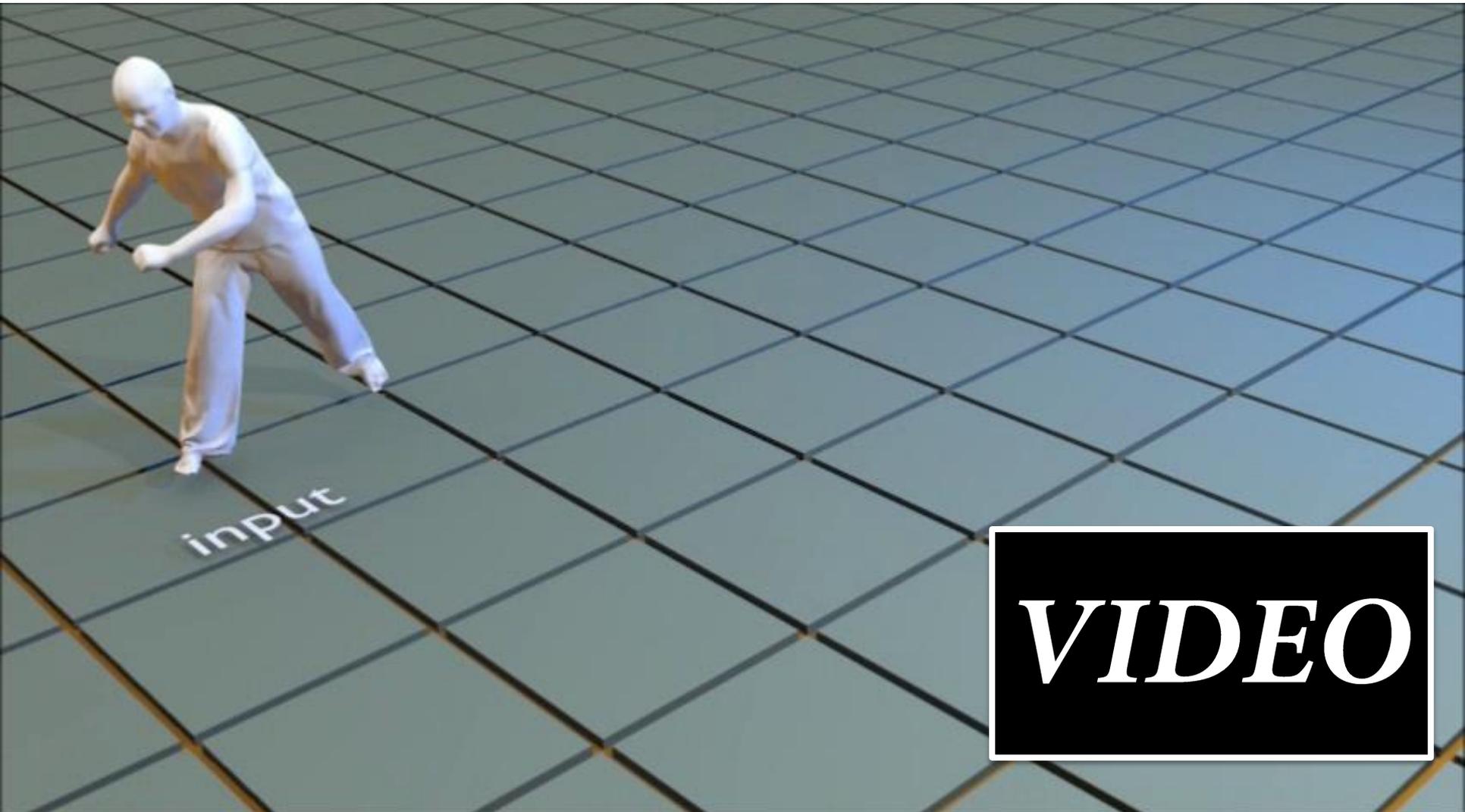
Analyse de formes



Analyse de formes

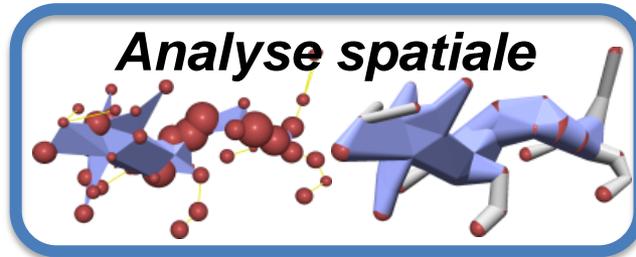


Analyse de formes animées

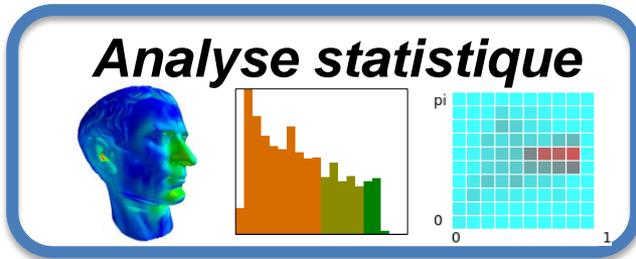


CageR [Thiery, Tierny, Boubekeur 2012]

Classes de méthodes discutées



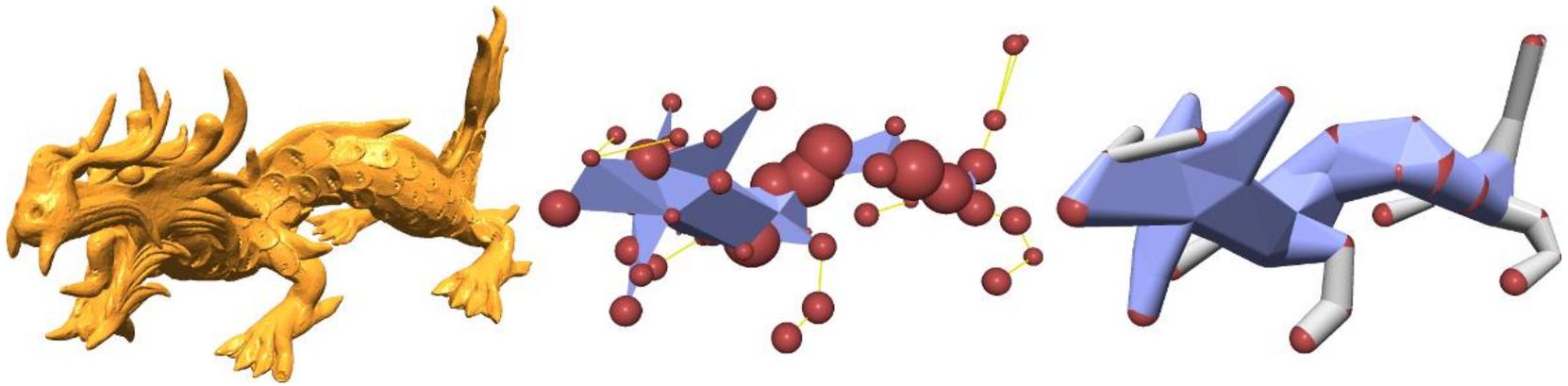
Sphere-Meshes



SimSelect

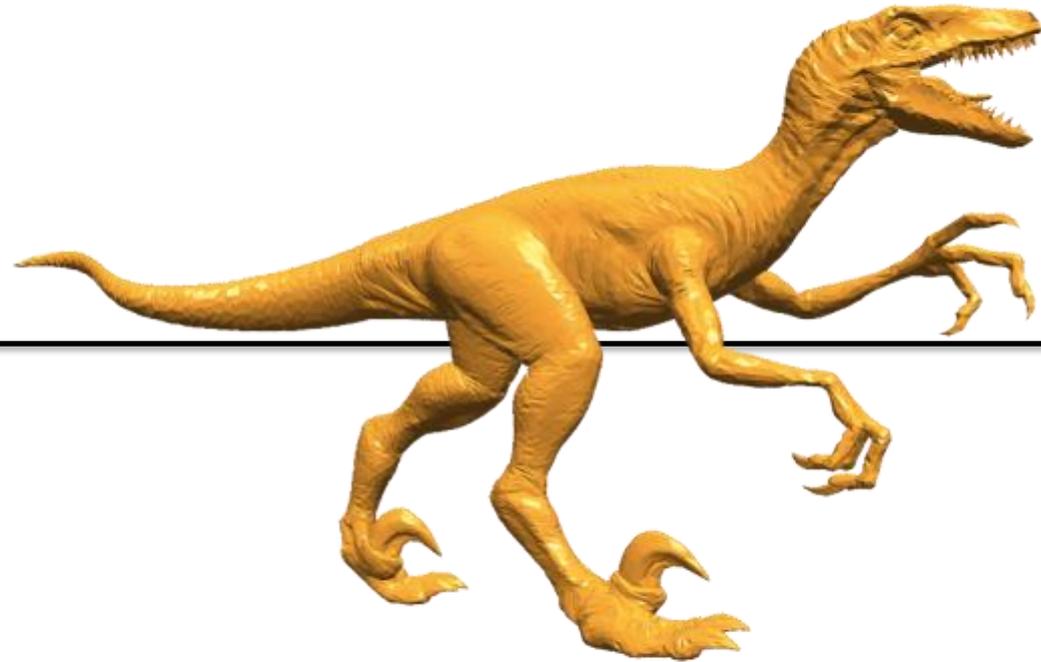


Morphologie par Points



ANALYSE SPATIALE

Comment approximer cette forme ?



Avec

1000

primitives ?

Simplification de maillage [Garland 1997]

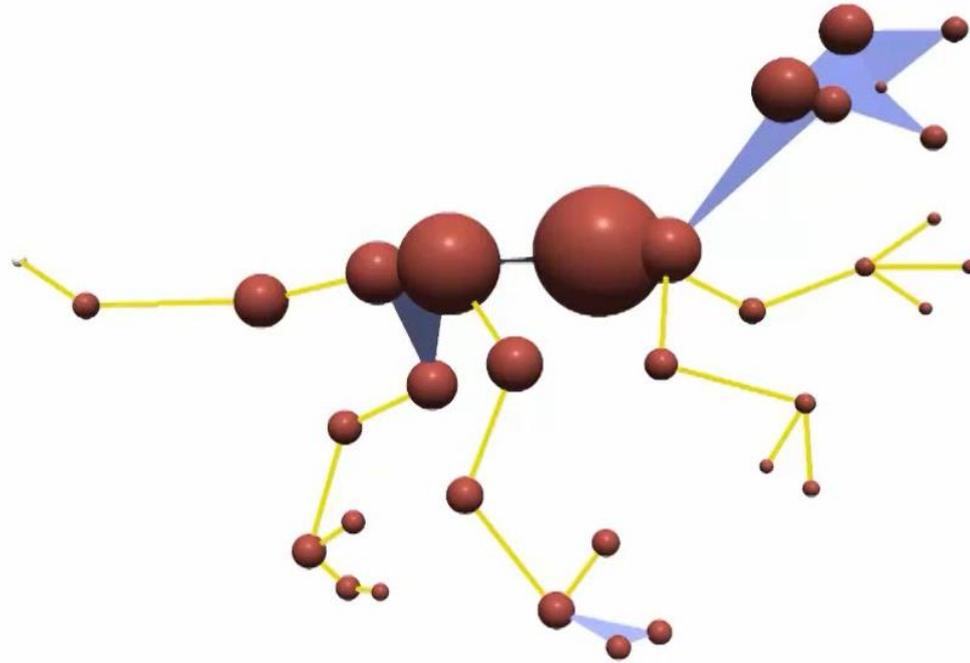


Avec

1000

primitives ?

Notre méthode

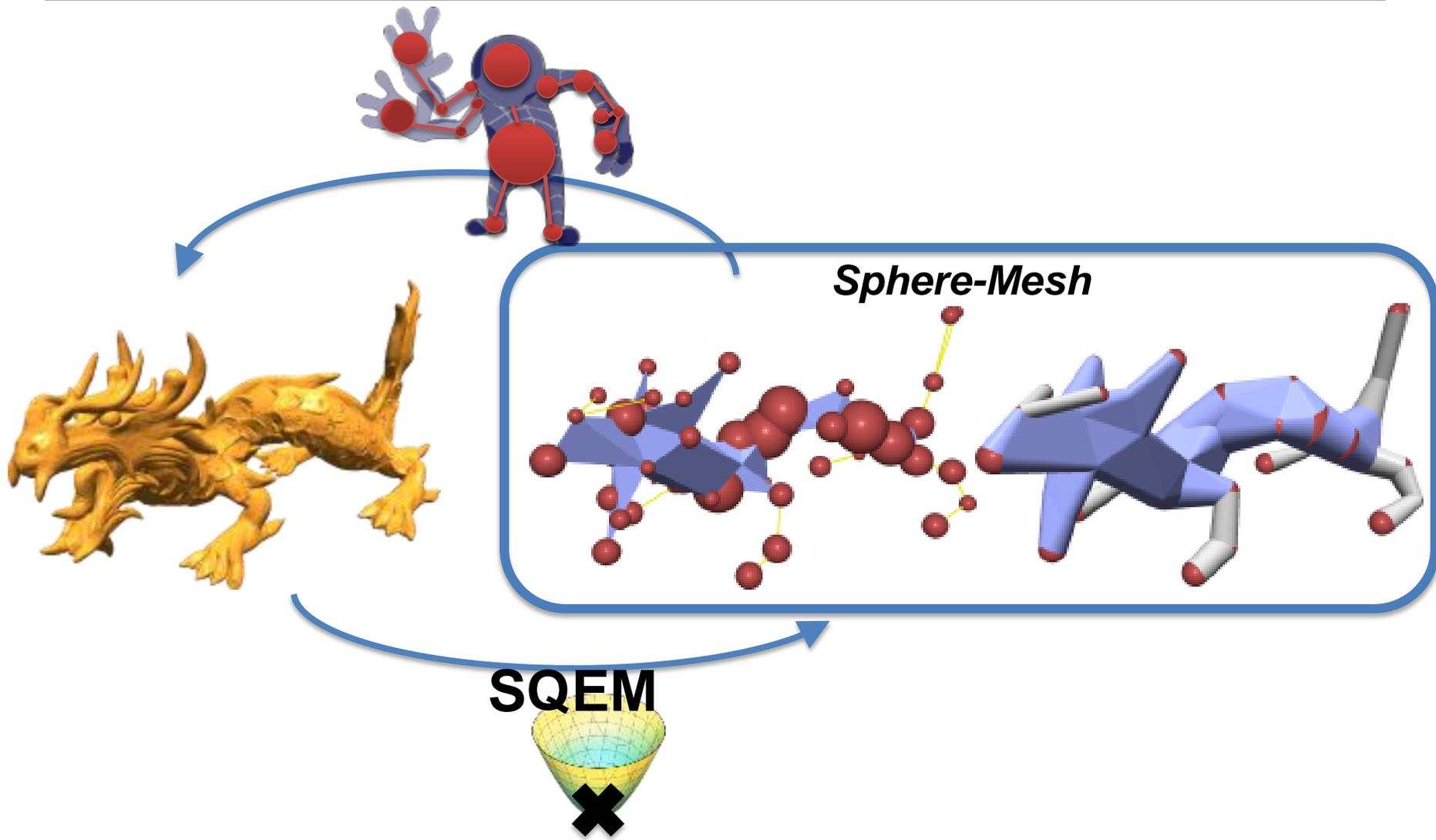


Avec

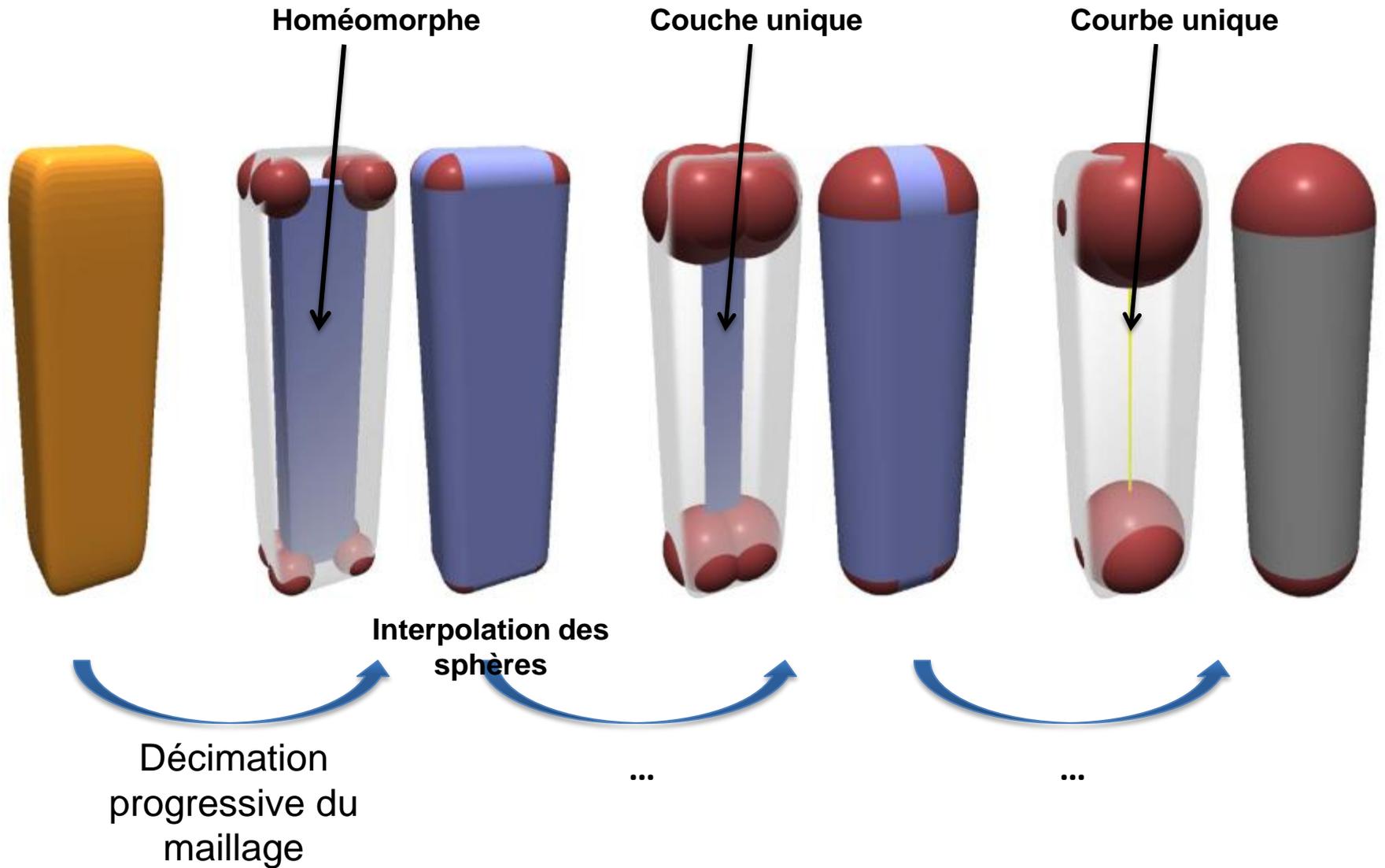
0035

primitives

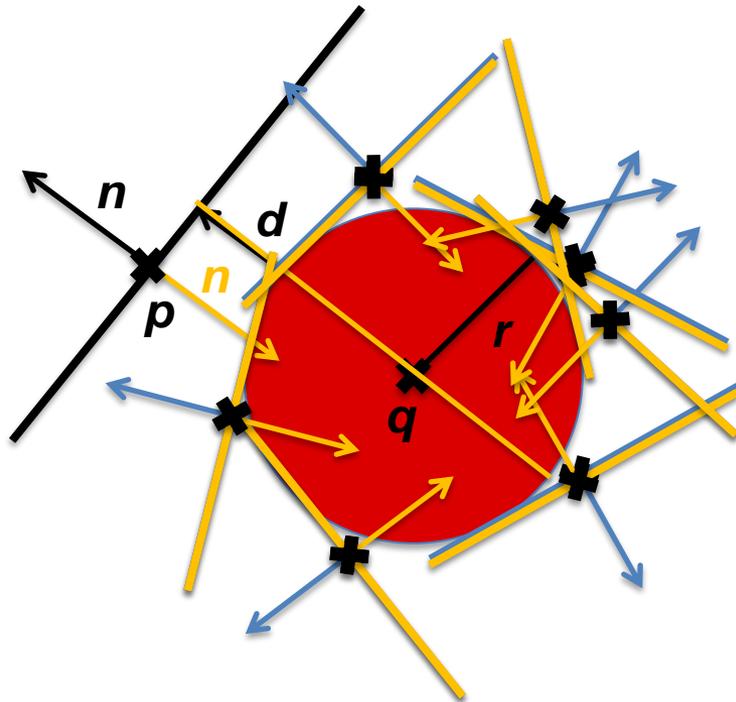
Vue d'ensemble



Algorithme d'approximation

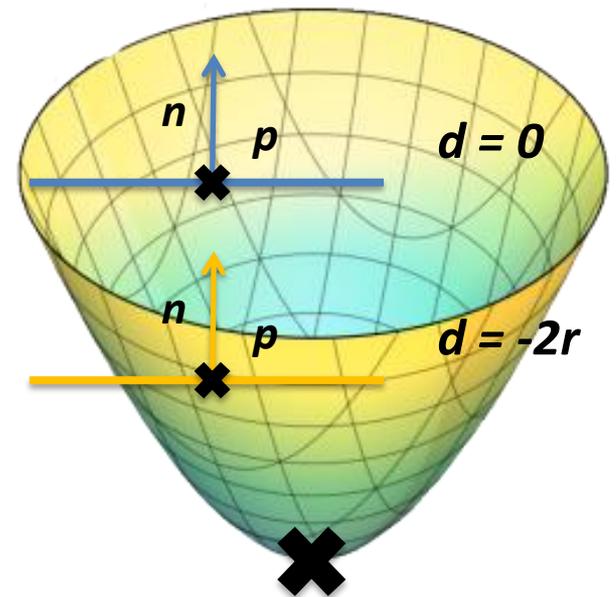


Quadrique d'Erreur Sphérique (SQEM)

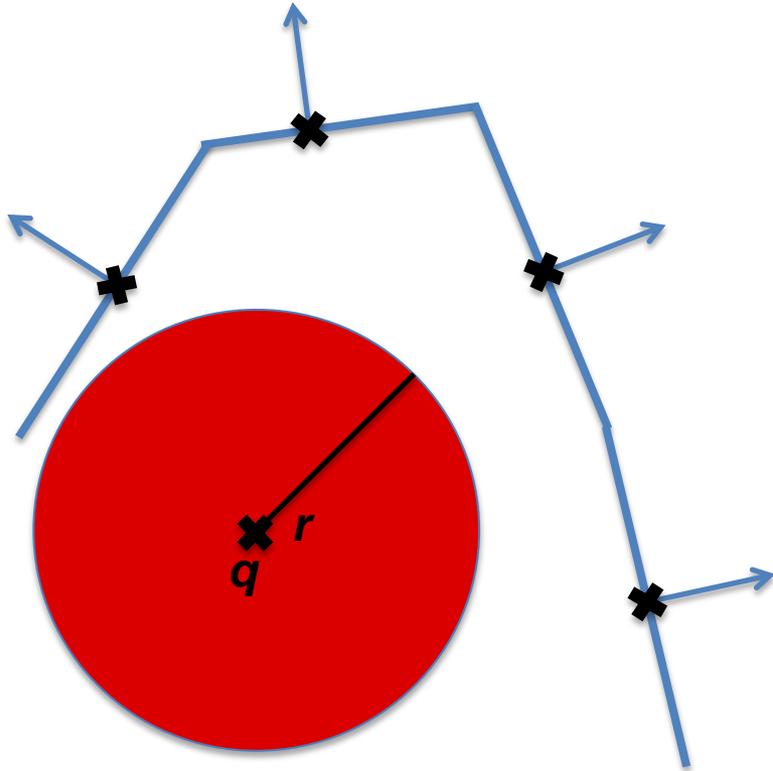


$$d = (p-q) \cdot n - r$$

$$SQEM(q,r) = d^2$$



Quadrique d'Erreur Sphérique (SQEM)



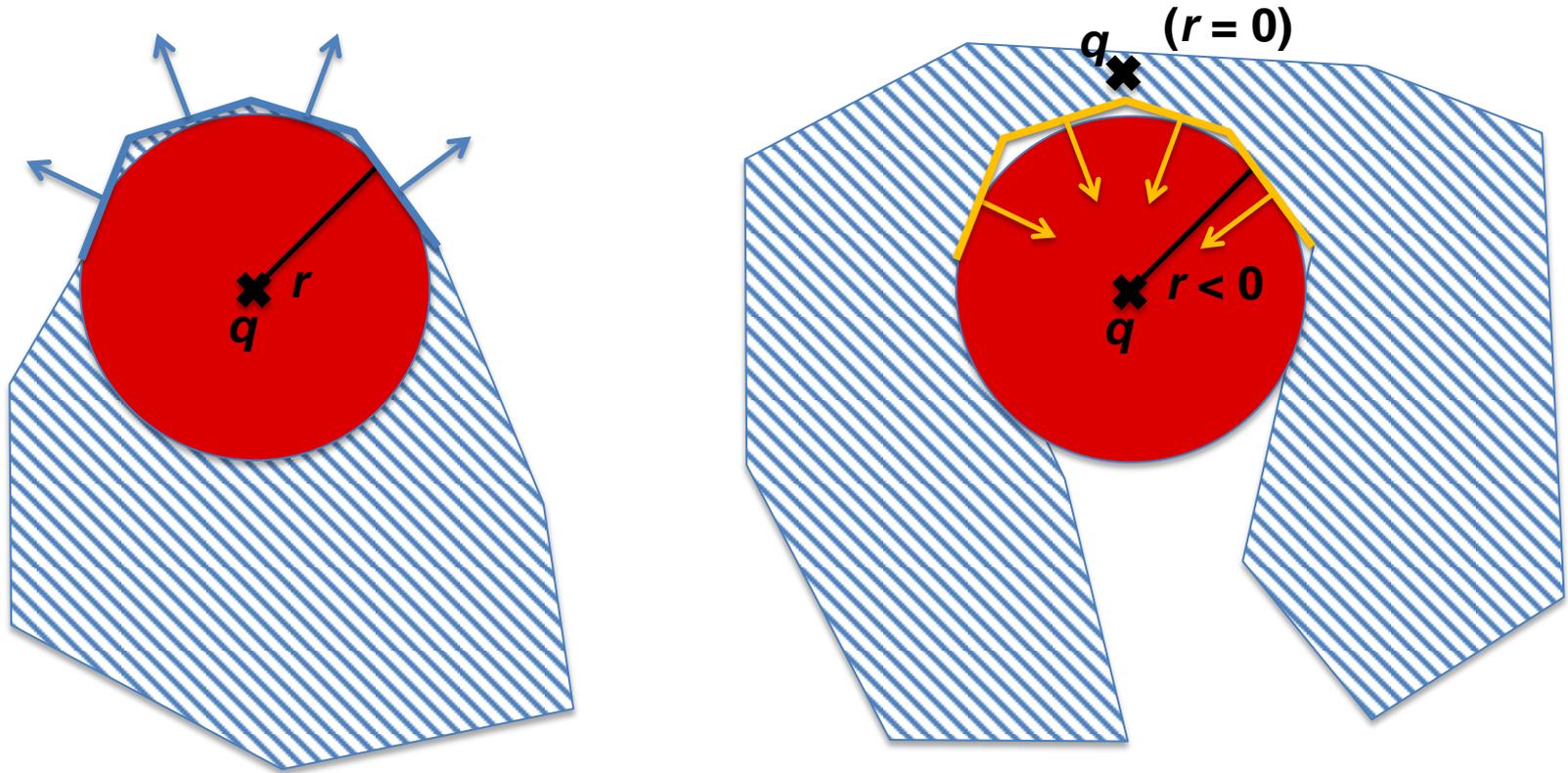
$$d^2\left(\begin{array}{c} n \\ \times \\ p \end{array}, \begin{array}{c} \times \\ r \\ q \end{array} \right) = \text{Cône}$$

$$\sum_i d^2\left(\begin{array}{c} n_i \\ \times \\ p_i \end{array}, \begin{array}{c} \times \\ r \\ q \end{array} \right) = \text{Cône} \times$$

Sphère optimale



Quadrique d'Erreur Sphérique(SQEM)



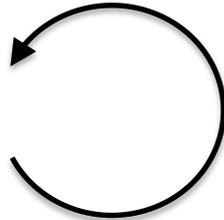
Minimisation de la SQEM sur $\mathbb{R}^3 \times \mathbb{R}^+$

Algorithme d'Approximation de Forme

Calculer SQEM 

Remplir Q 

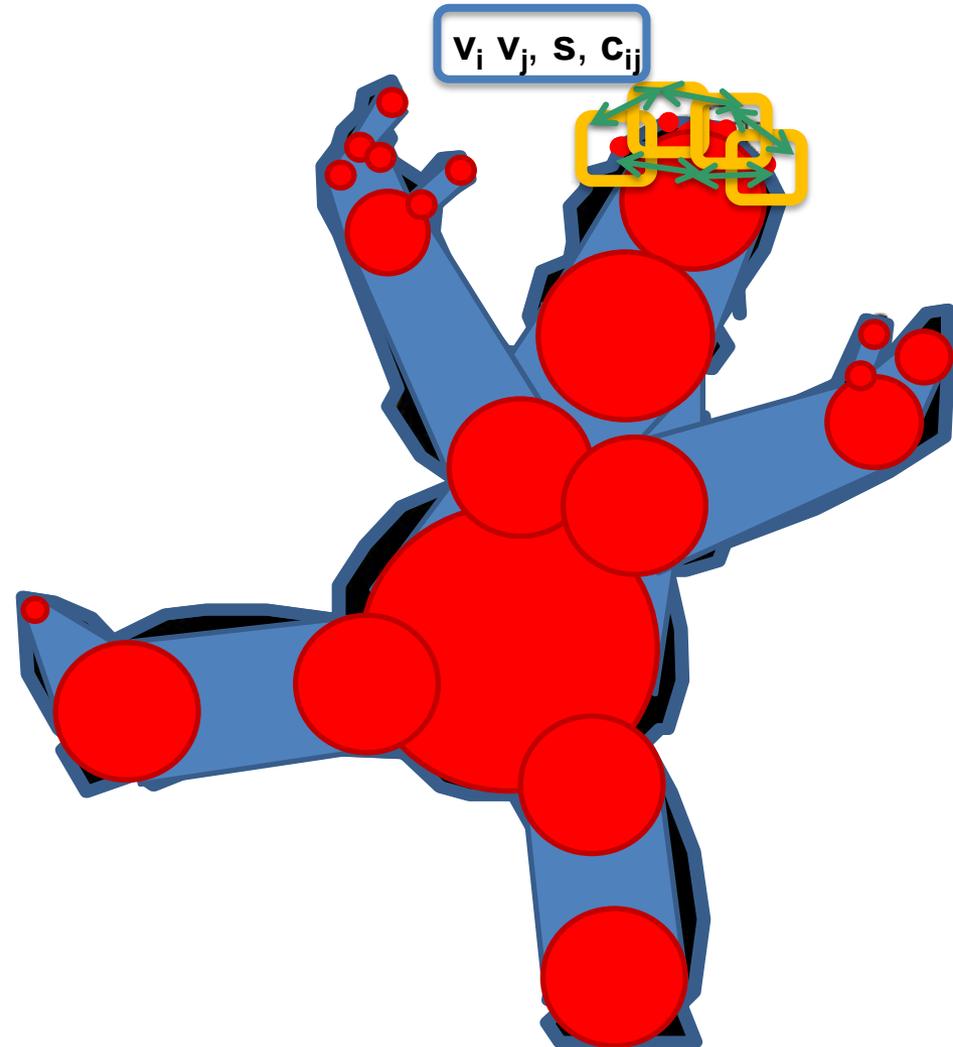
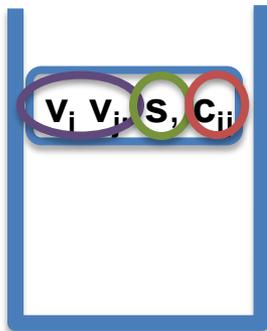
- Contraction minimale
- Mise à jour de Q 



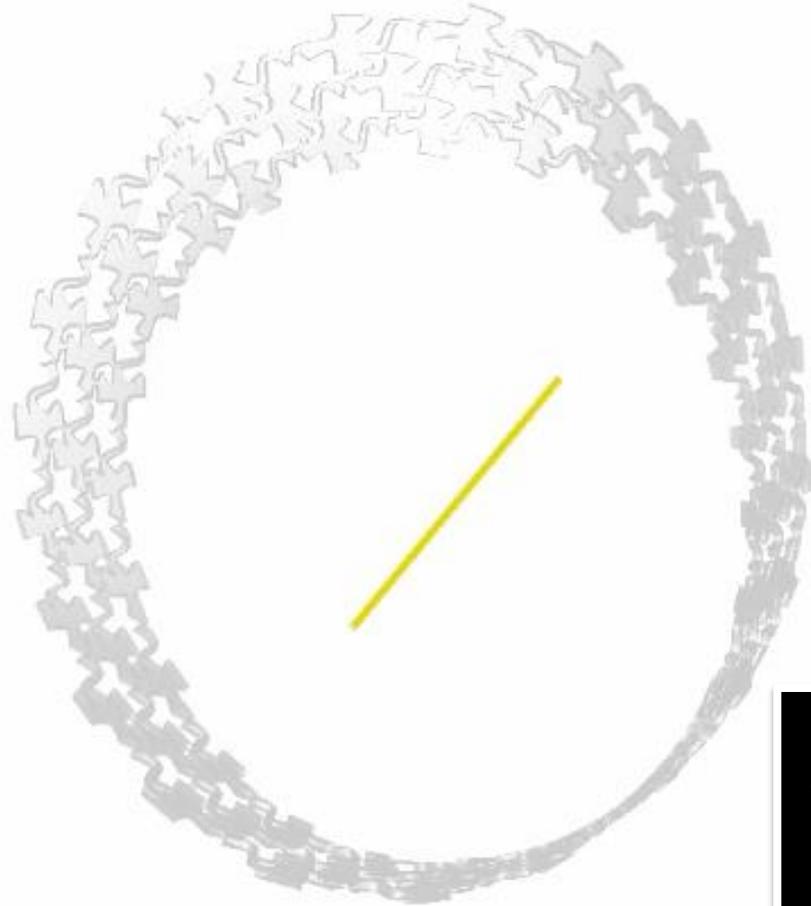
Coût de contraction
Sphère optimale
Sommets voisins

File à
priorité

Q :



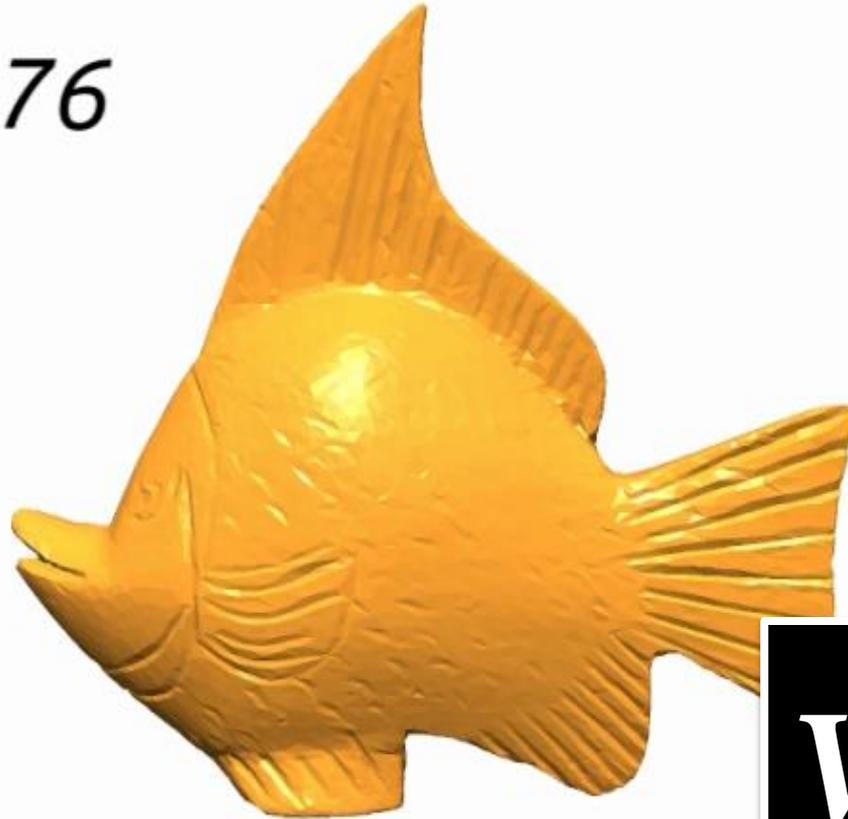
2



VIDEO

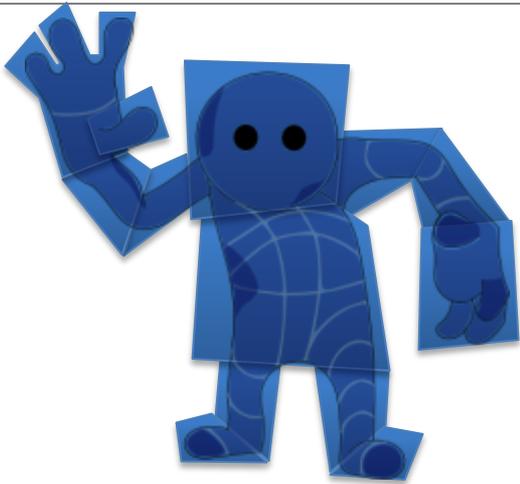
Application

7376

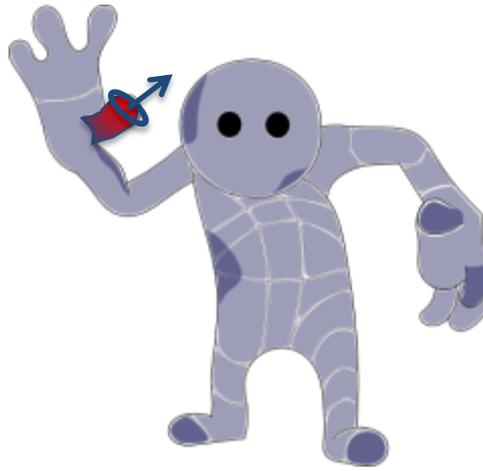


VIDEO

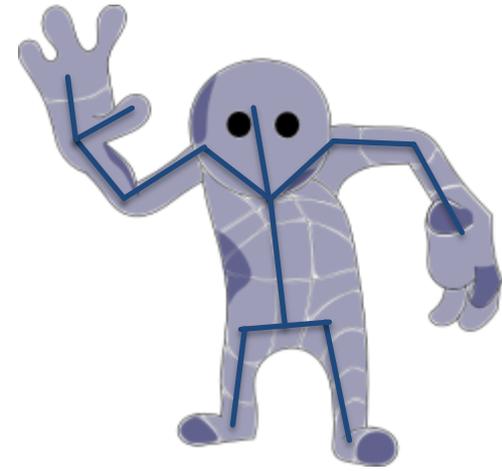
Application à la déformation interactive



Cages [Lipman, 2008]



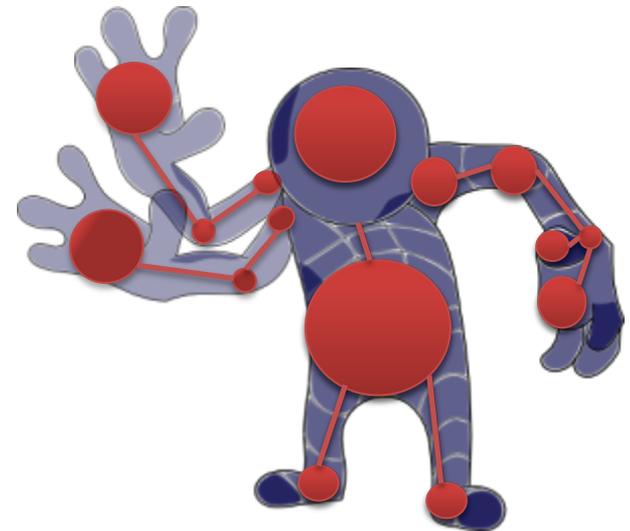
Poignées [Sorkine, 2004]



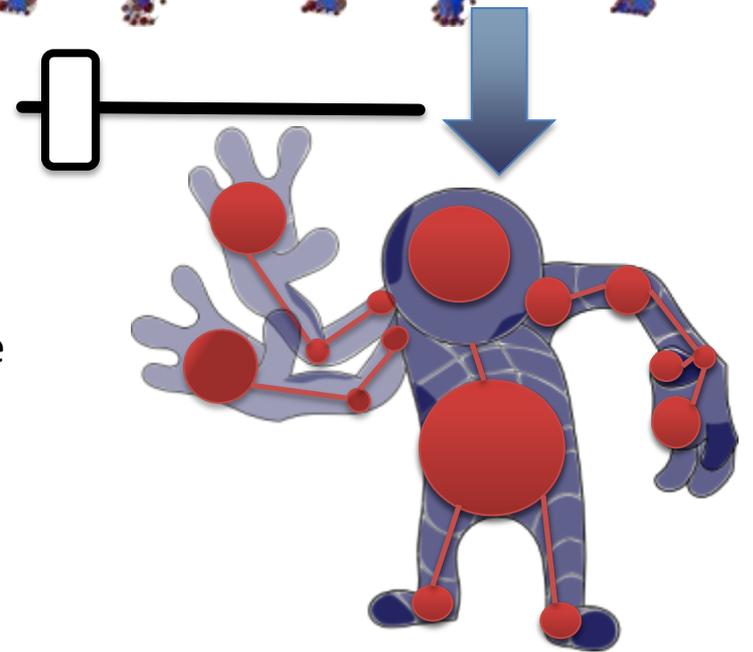
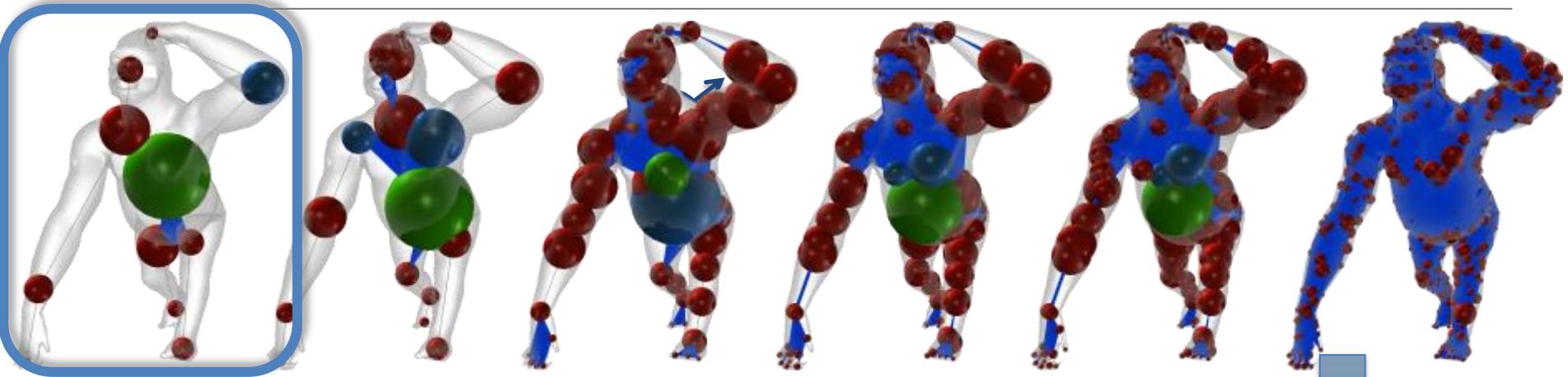
Squelette

Sphere-mesh = contrôle de haut niveau ?

- Dimensionnalité dynamique selon l'échelle
- Construction automatique
- Structure multi-résolution naturelle



Application à la déformation interactive



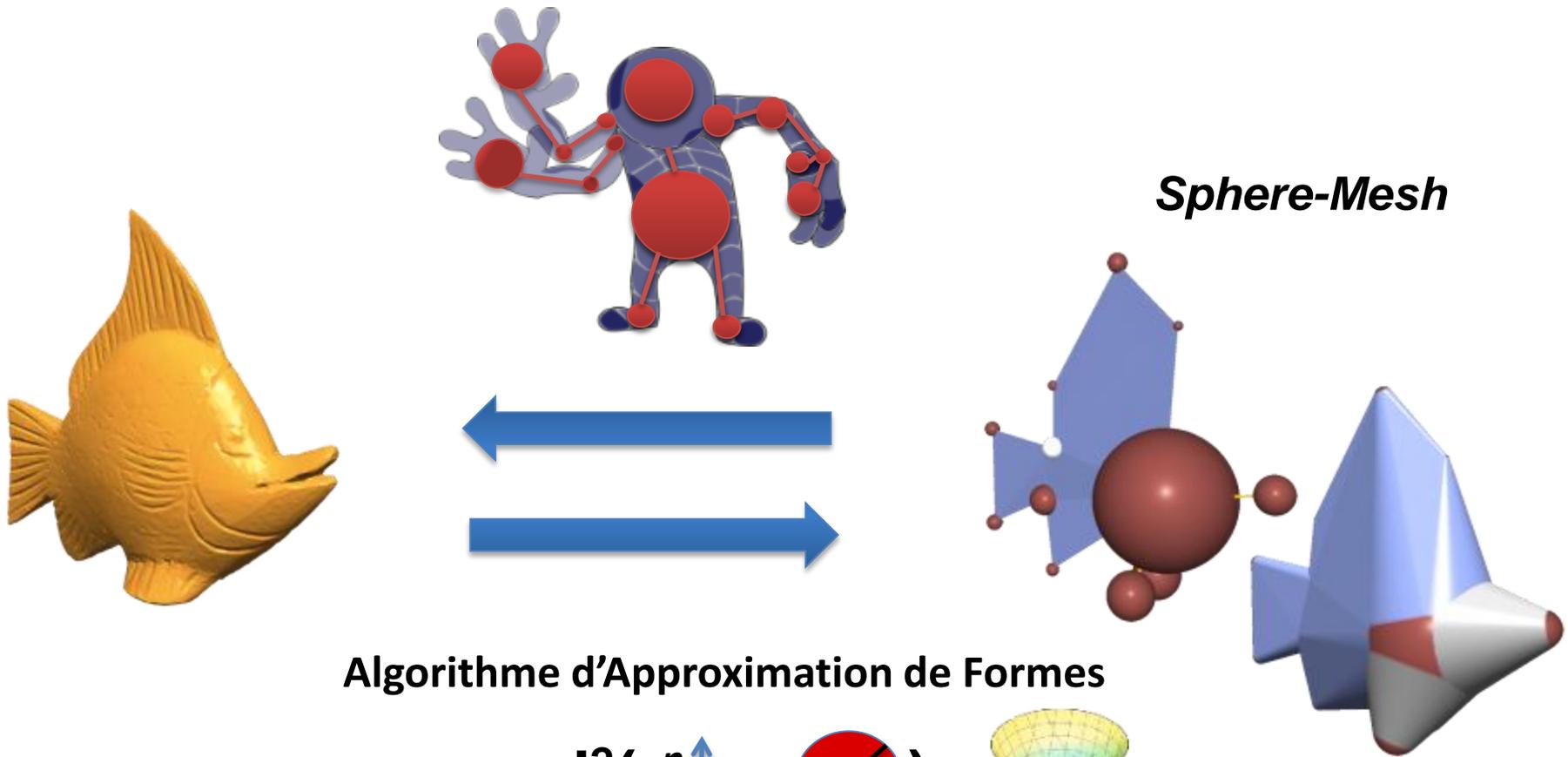
Sphere-mesh = contrôle de haut niveau ?

- Dimensionnalité dynamique selon l'échelle
- Construction automatique
- Structure multi-résolution naturelle



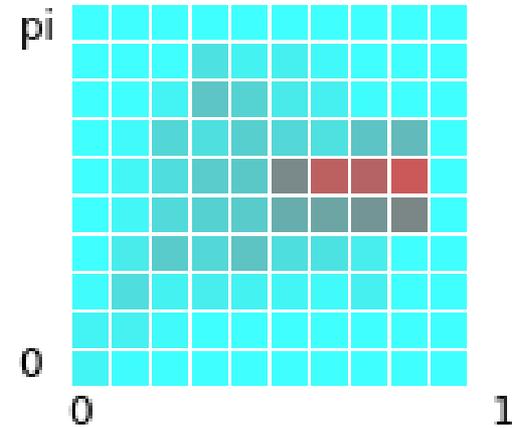
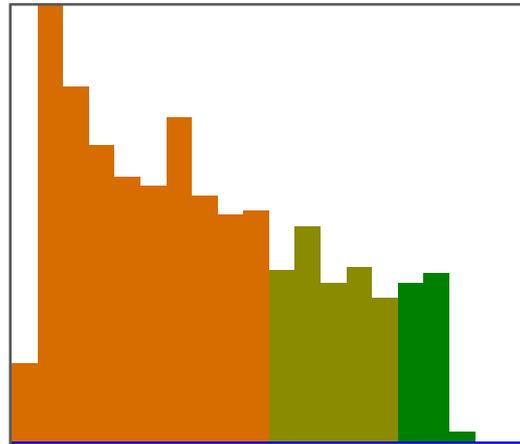
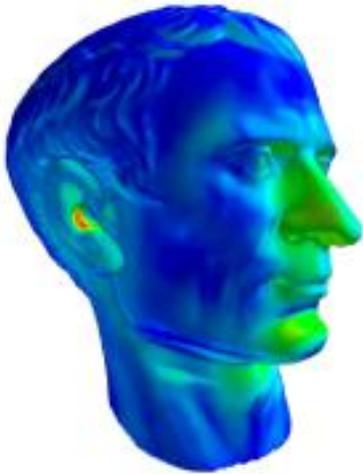
VIDEO

Analyse spatiale pour l'approximation et le contrôle de forme



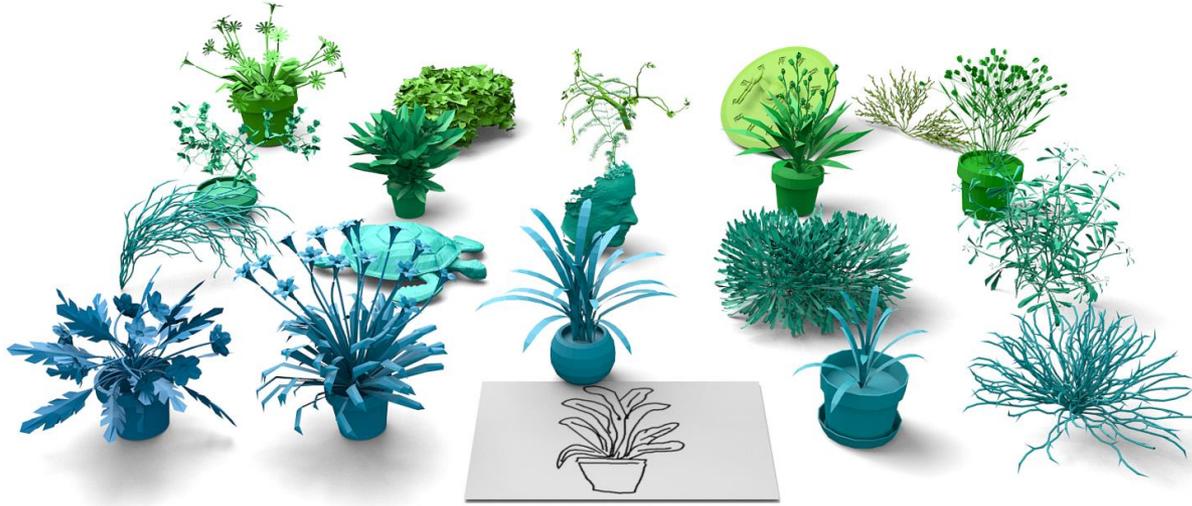
SQEM

$$d^2\left(\begin{matrix} n \\ \uparrow \\ \times \\ \downarrow \\ p \end{matrix}, \begin{matrix} \times \\ \downarrow \\ q \\ \uparrow \\ r \end{matrix} \right) = \text{[Bowl-shaped mesh]}$$



ANALYSE STATISTIQUE

Inspiration : moteur de recherche de formes 3D

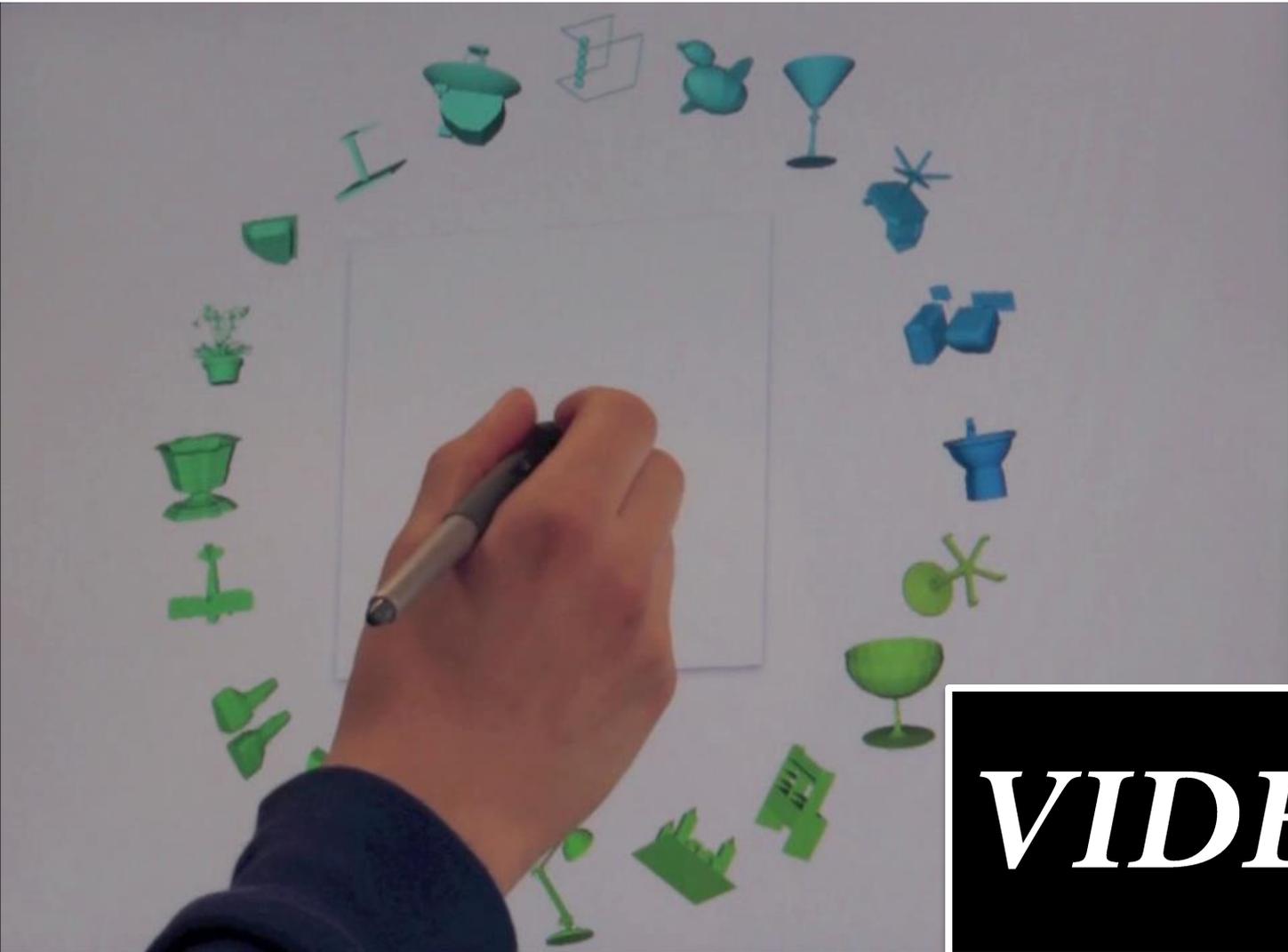


Modélisation interactive conduite par les données



[Eitz, Richter, Boubekeur, Hildebrand, Alexa 2012]

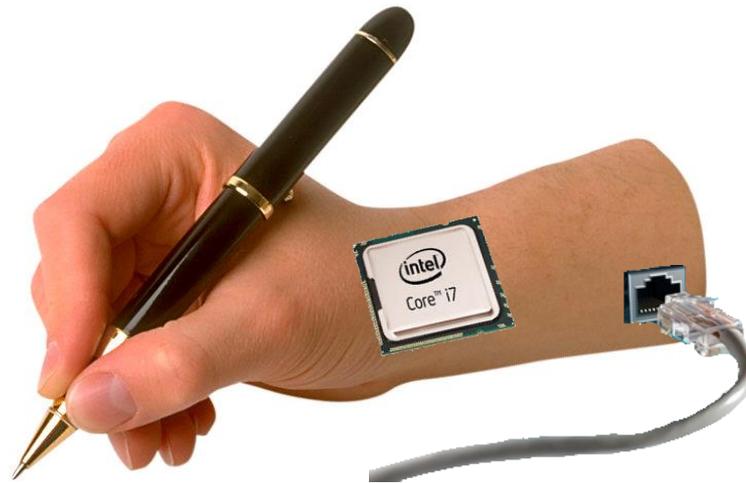
Inspiration : moteur de recherche de formes 3D



VIDEO

[Eitz, Richter, Boubekeur, Hildebrand, Alexa 2012]

Interaction Computationnelle





components



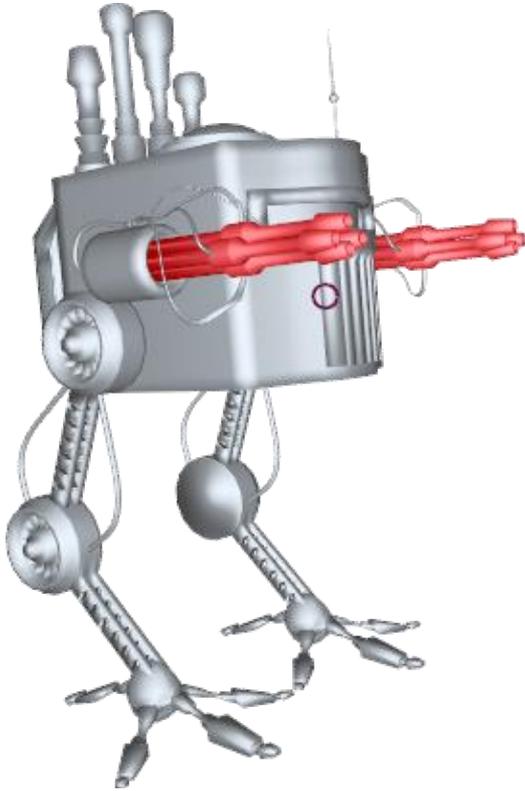
parts



patches

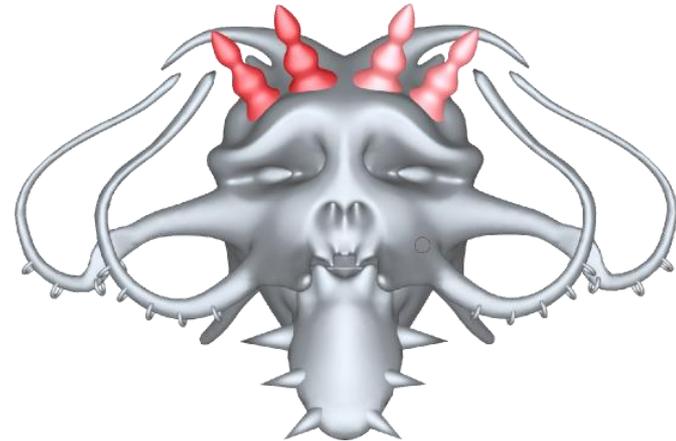
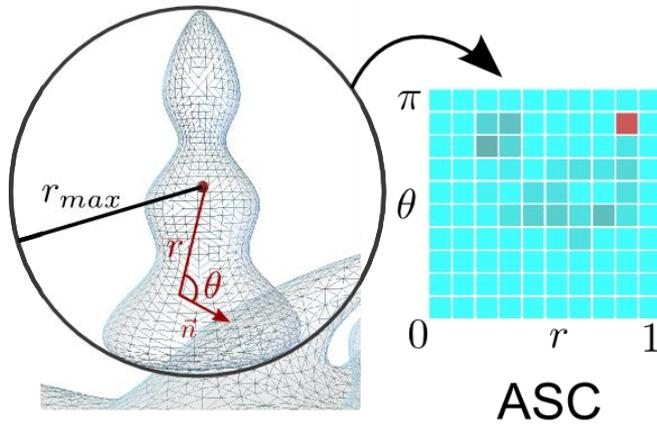
VIDEO

Détection de similarités

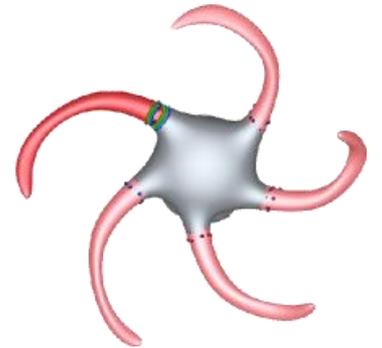
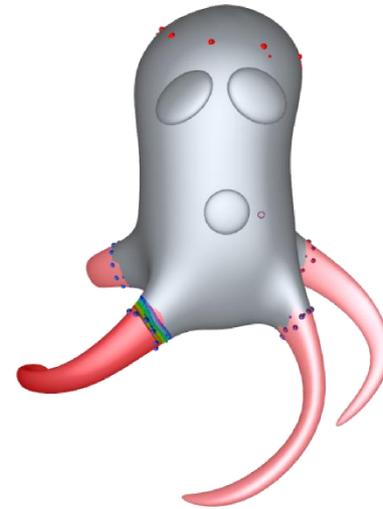
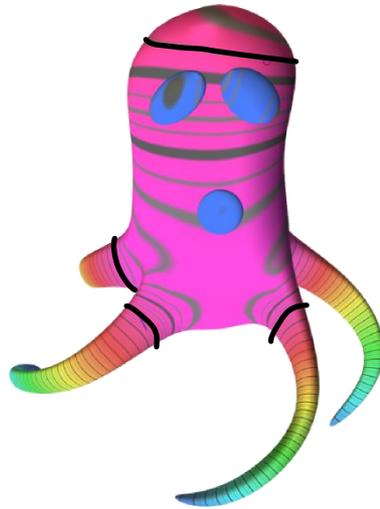
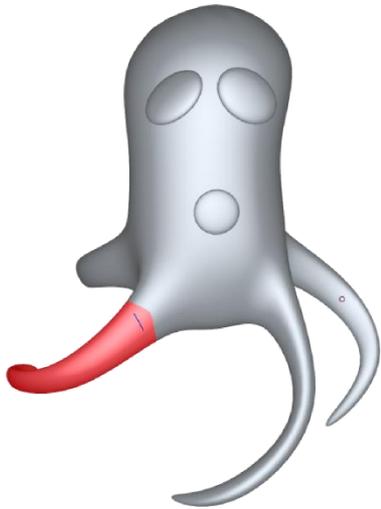


Composantes similaires

1. Descripteur de composante : Contexte de Forme Approximé (ASC)
2. Distances entre ASC

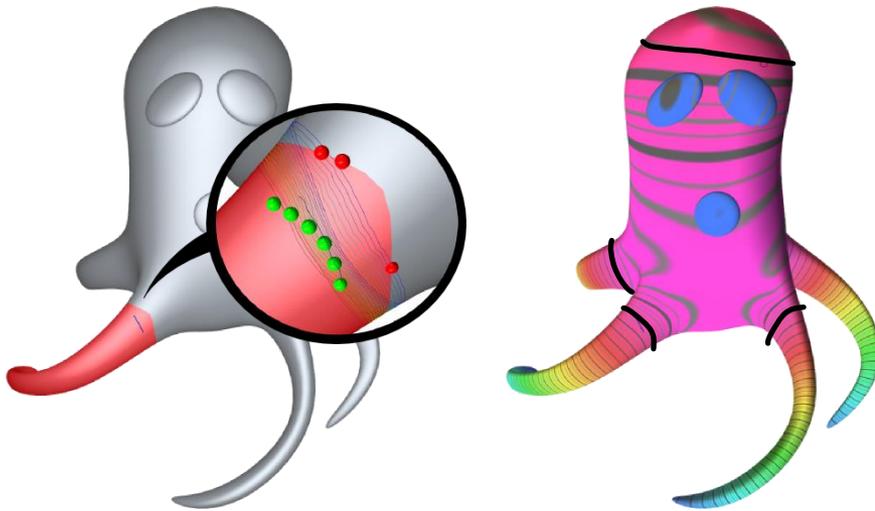


Parties similaires



[Ben-Chen 2008]

Parties similaires



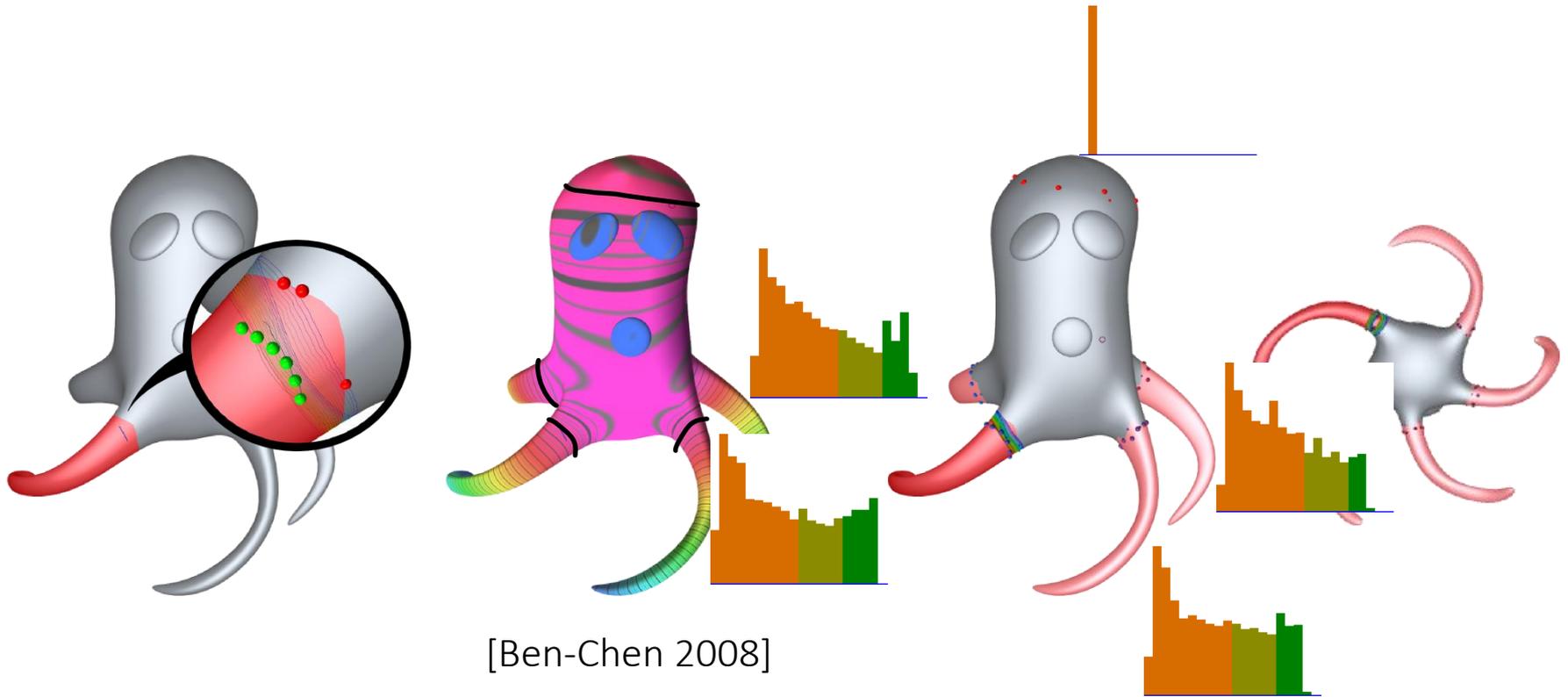
[Ben-Chen 2008]

Facteur de Conformalité

$$L\Phi = \underset{\substack{\uparrow \\ \text{courbure cible}}}{K^T} - \overset{\substack{\rightarrow \\ \text{courbure de la surface}}}{K^{origin}}$$

invariant aux déformations
isométriques

Parties similaires



[Ben-Chen 2008]

Régions similaires



Région de référence



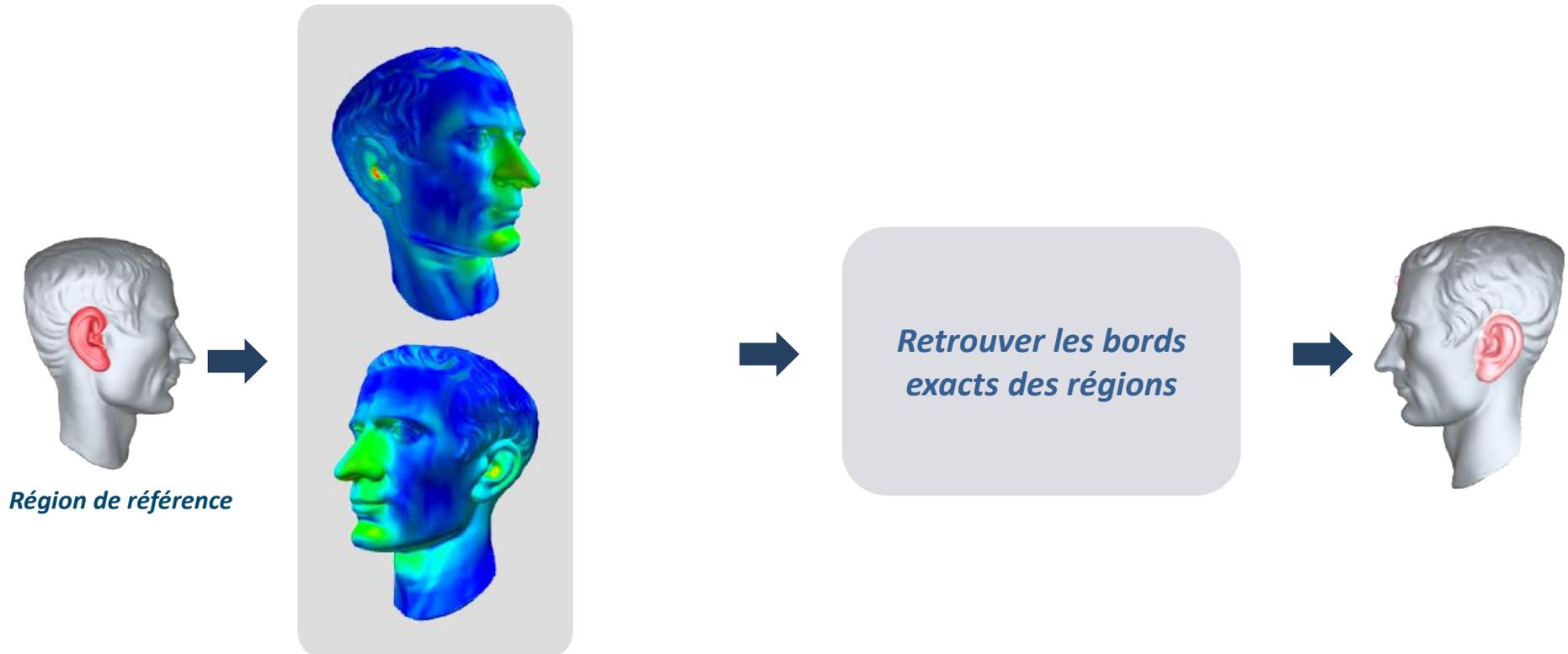
*Trouver les k
centres les
plus
similaires*



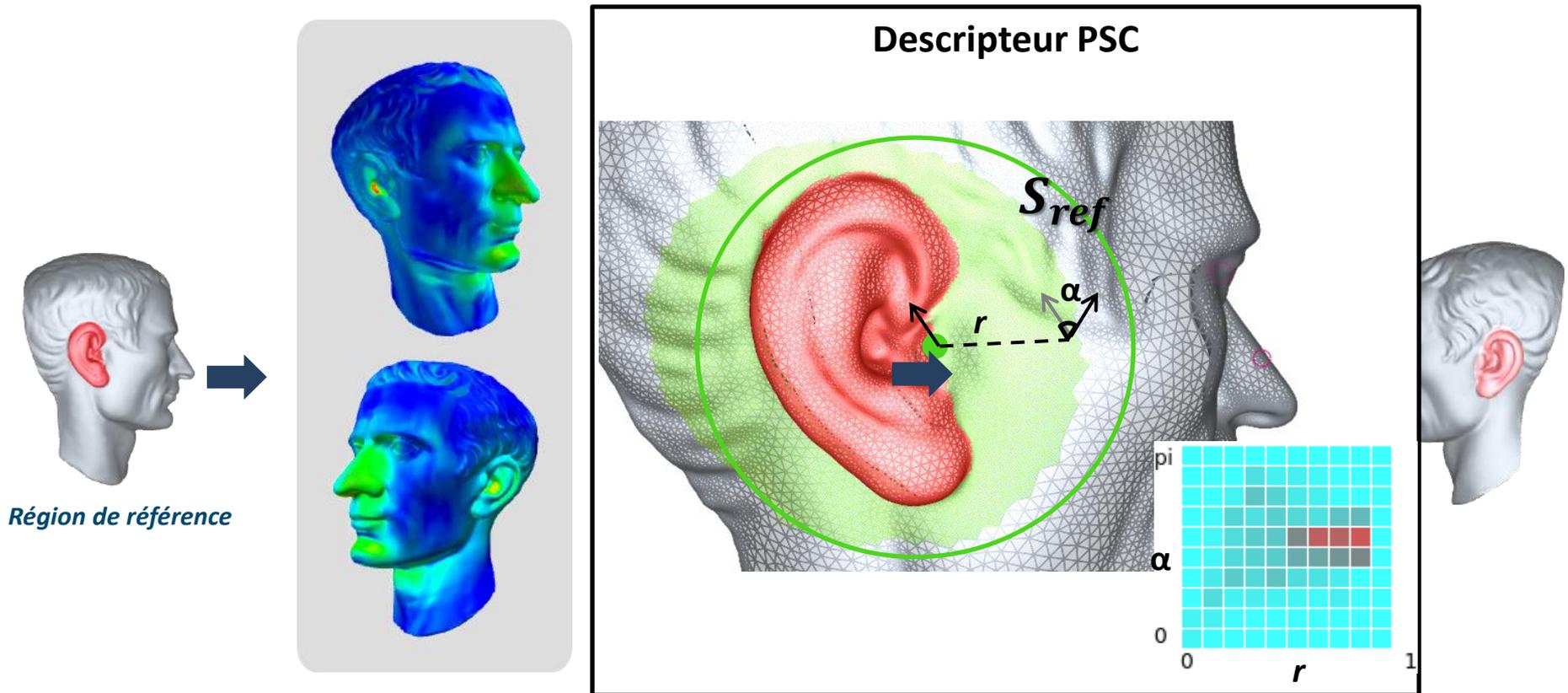
*Retrouver les bords
exacts des régions*



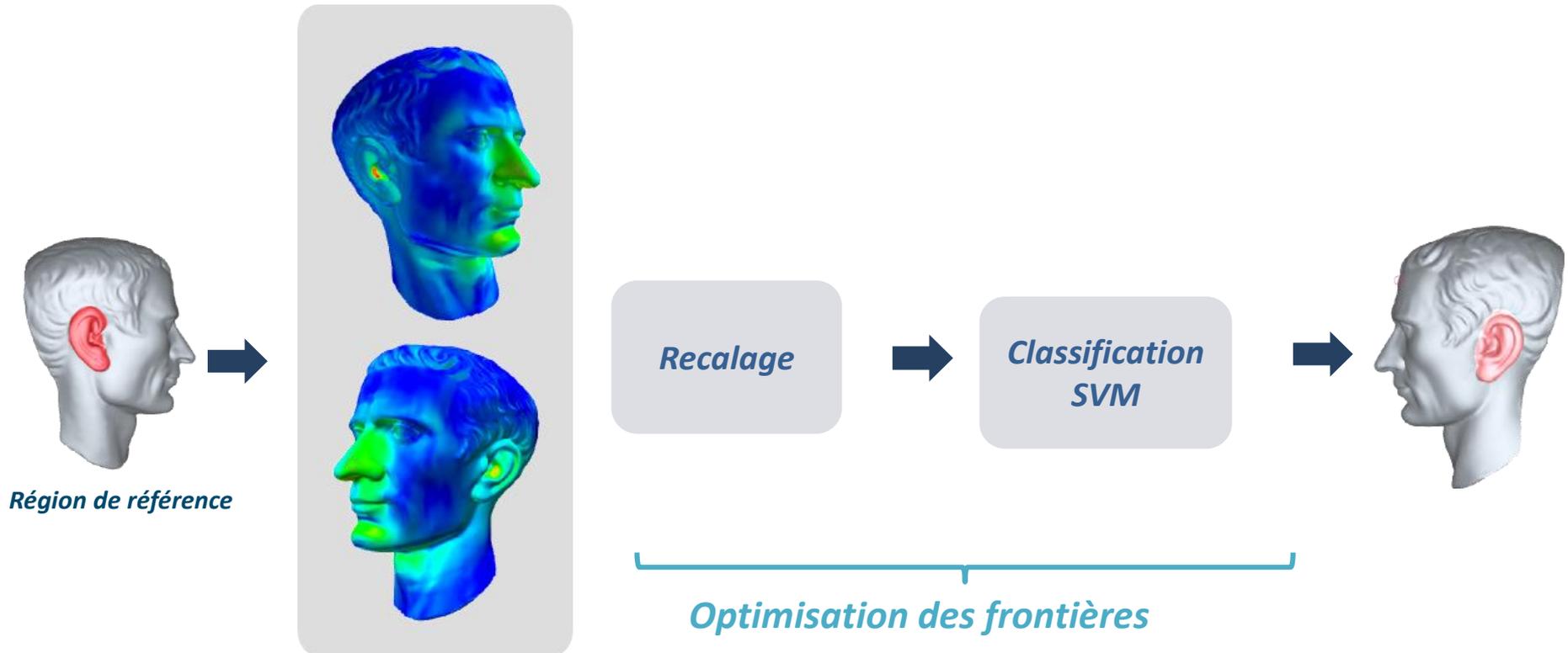
Régions similaires



Régions similaires

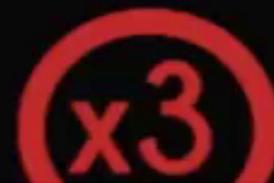


Régions similaires



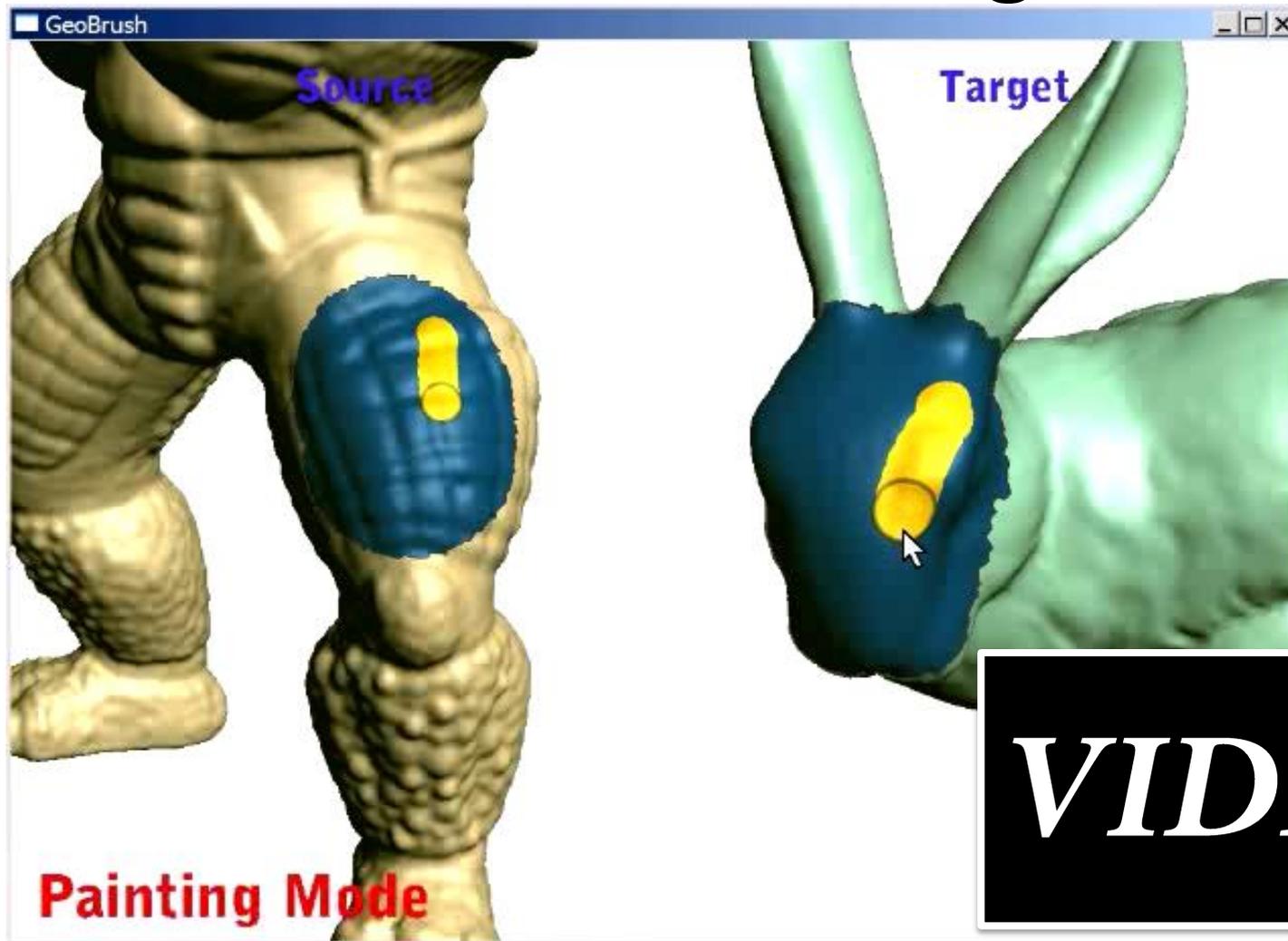
Goro

(82k vertices, 165k faces)

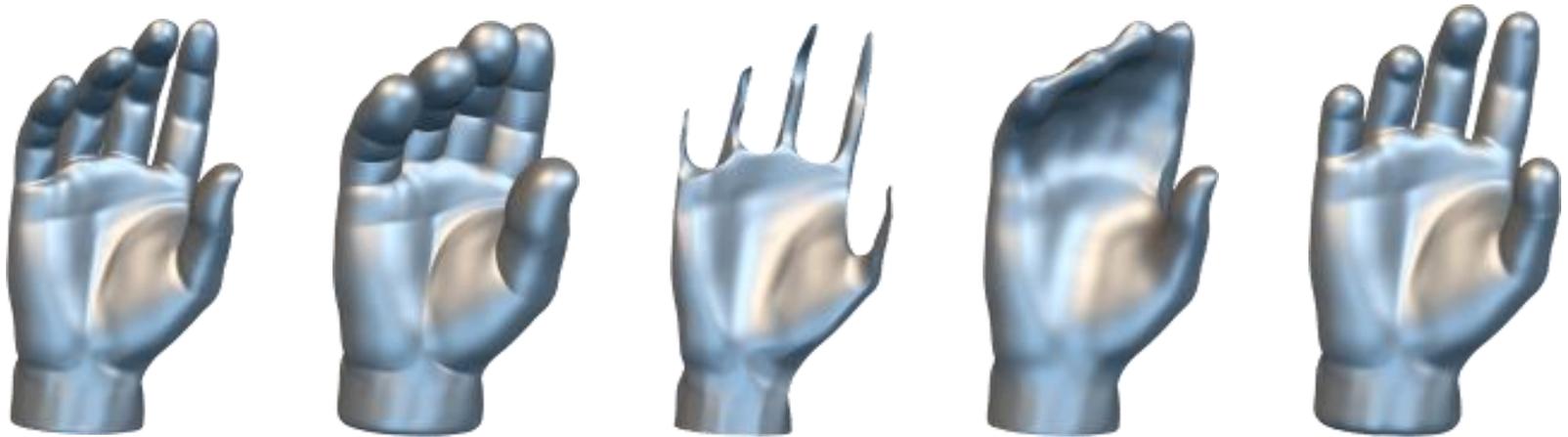


VIDEO

Dessiner & mélanger

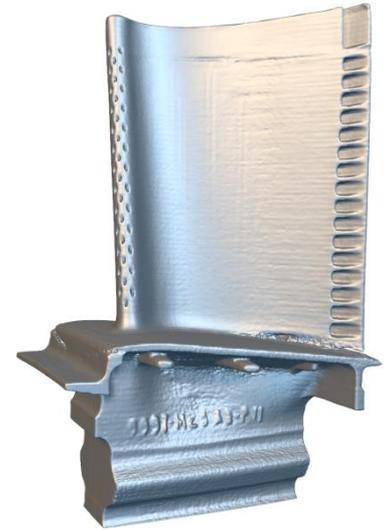
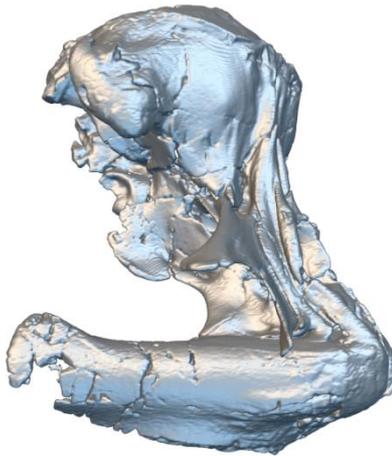
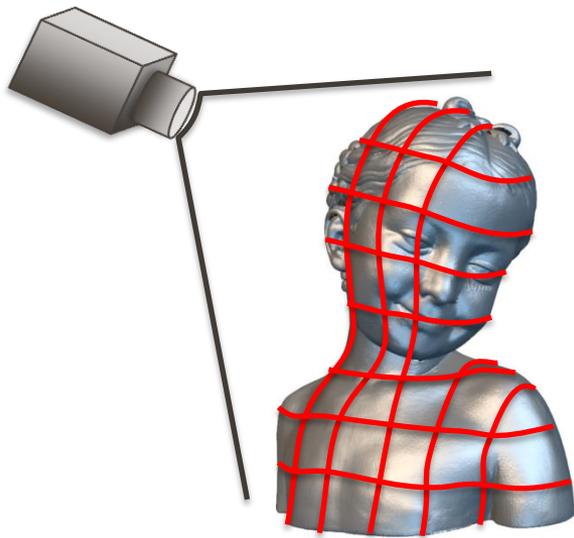


[Takayama, Schmidt, Singh, Igarashi, Boubekeur, Sorkine 2011]

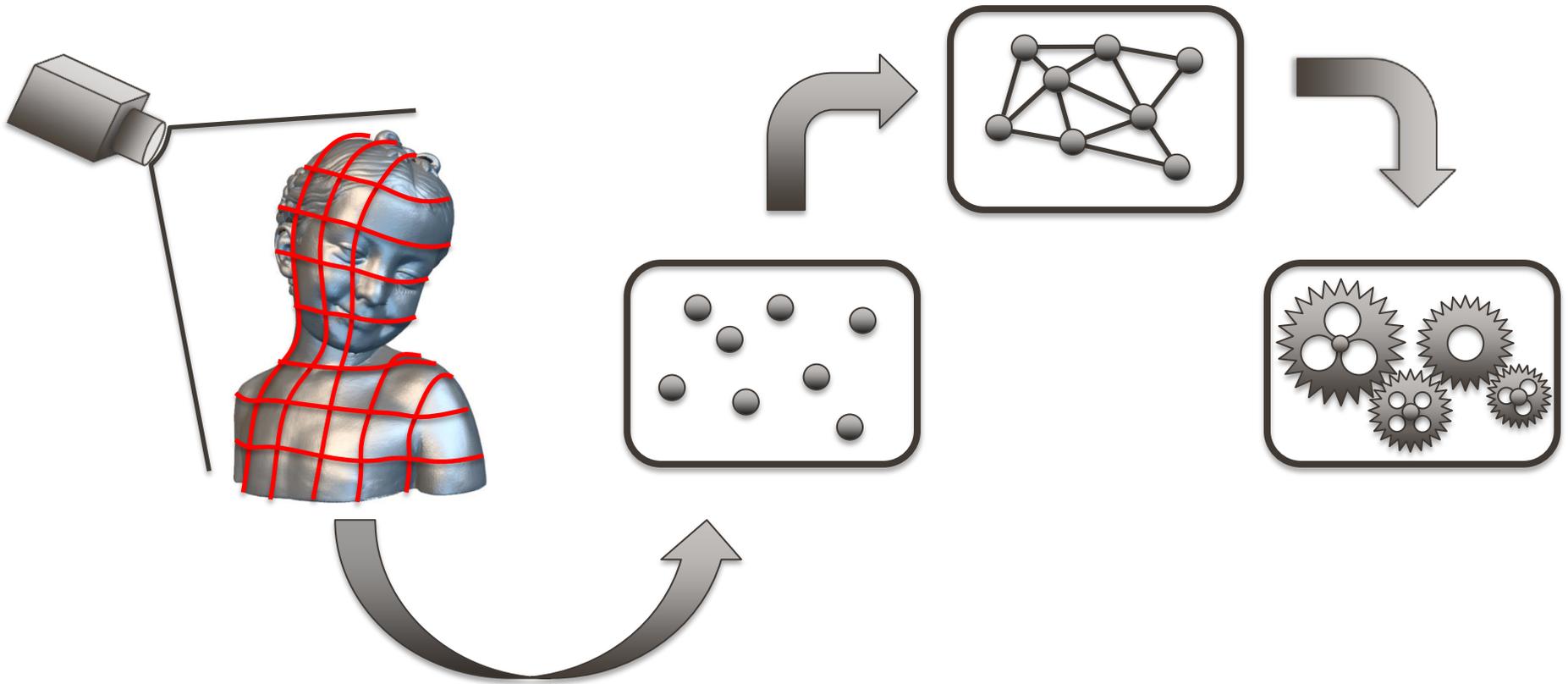


ANALYSE MORPHOLOGIQUE

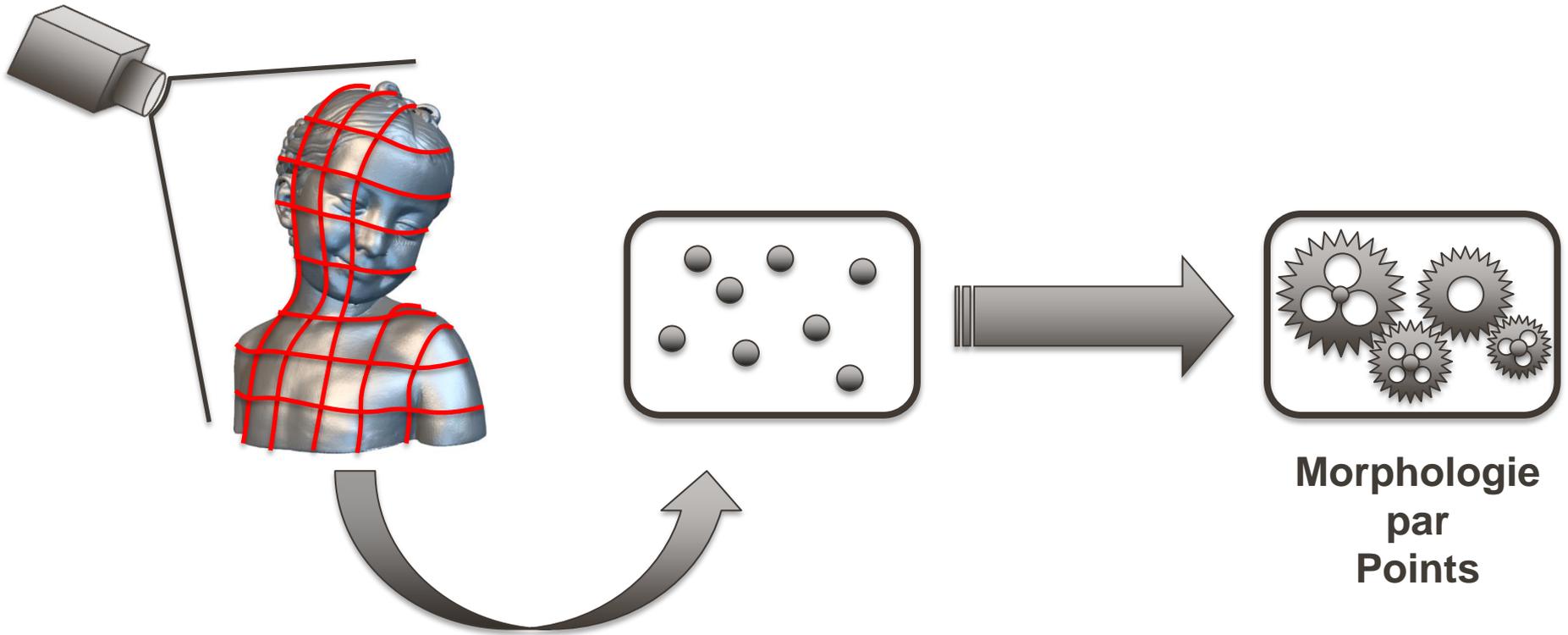
Chaîne de capture 3D



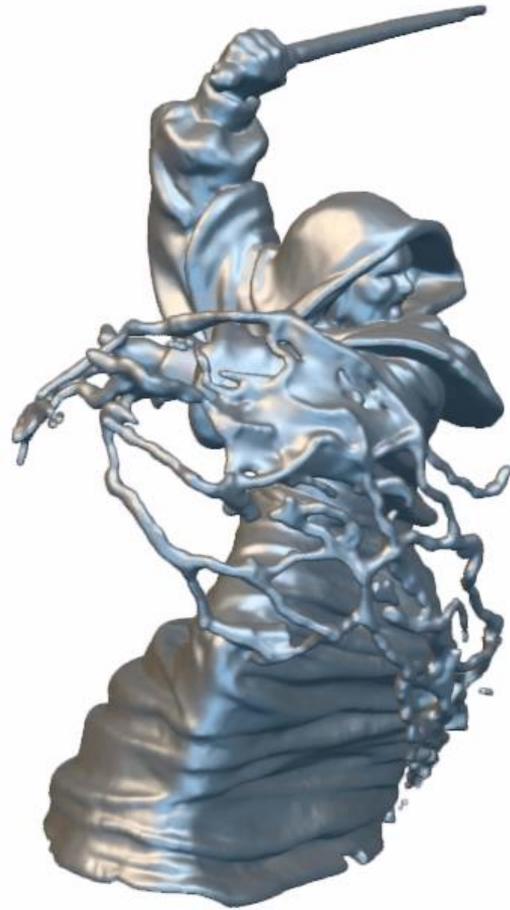
Chaîne de capture 3D



Chaîne de capture 3D

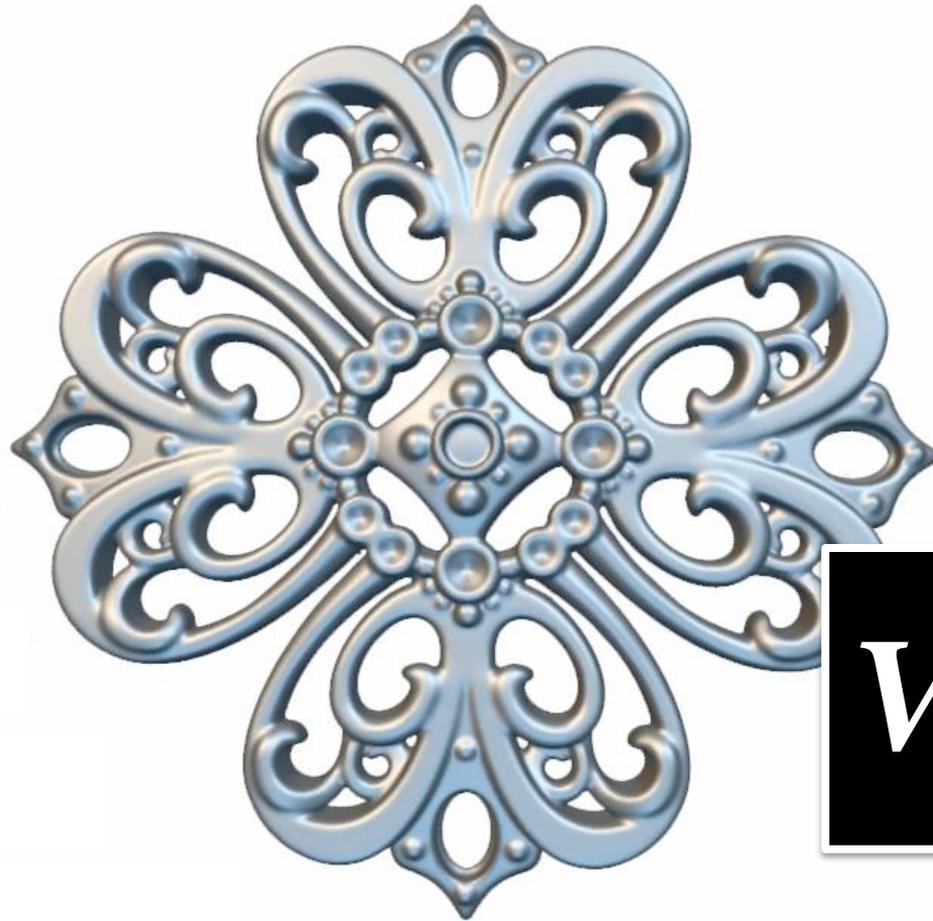


Filtrage de forme



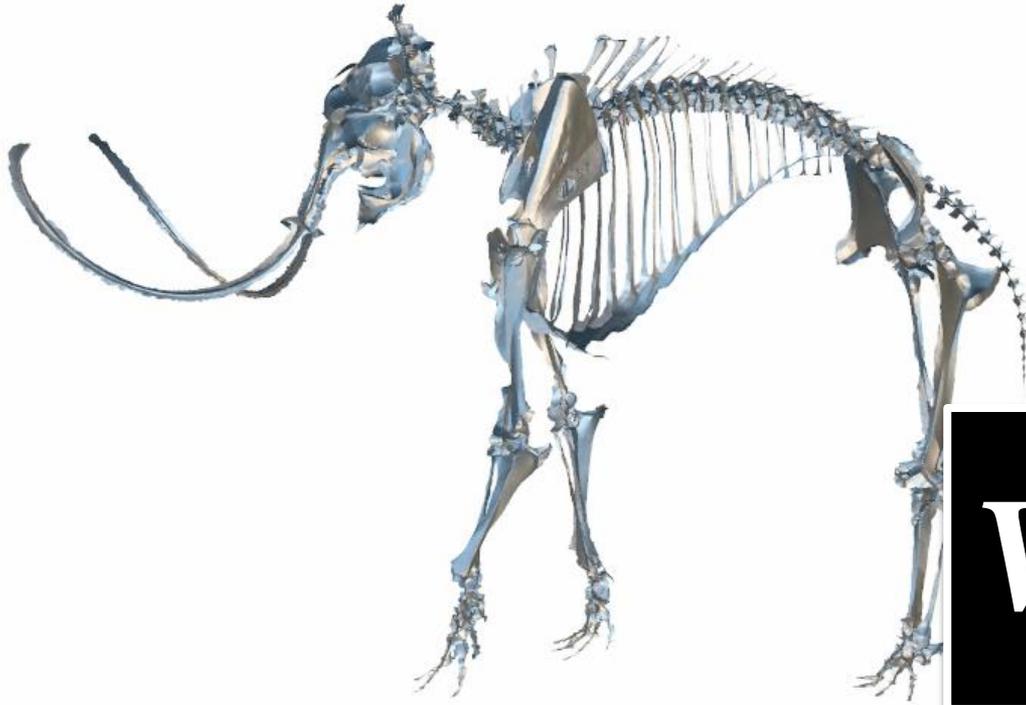
VIDEO

Simplification de topologie



VIDEO

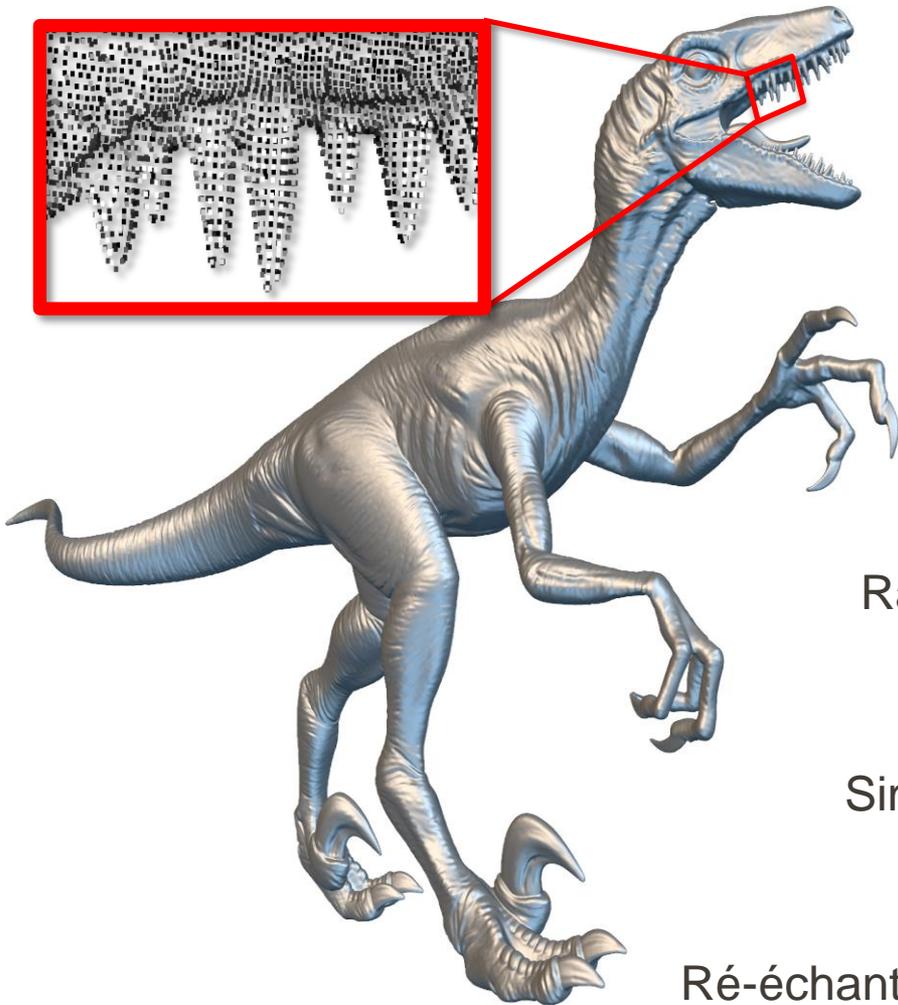
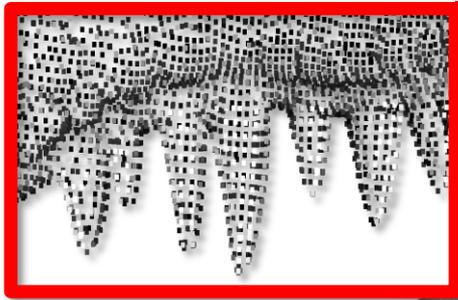
Evaluation d'axe médian



VIDEO

Surfaces de points (PSS)

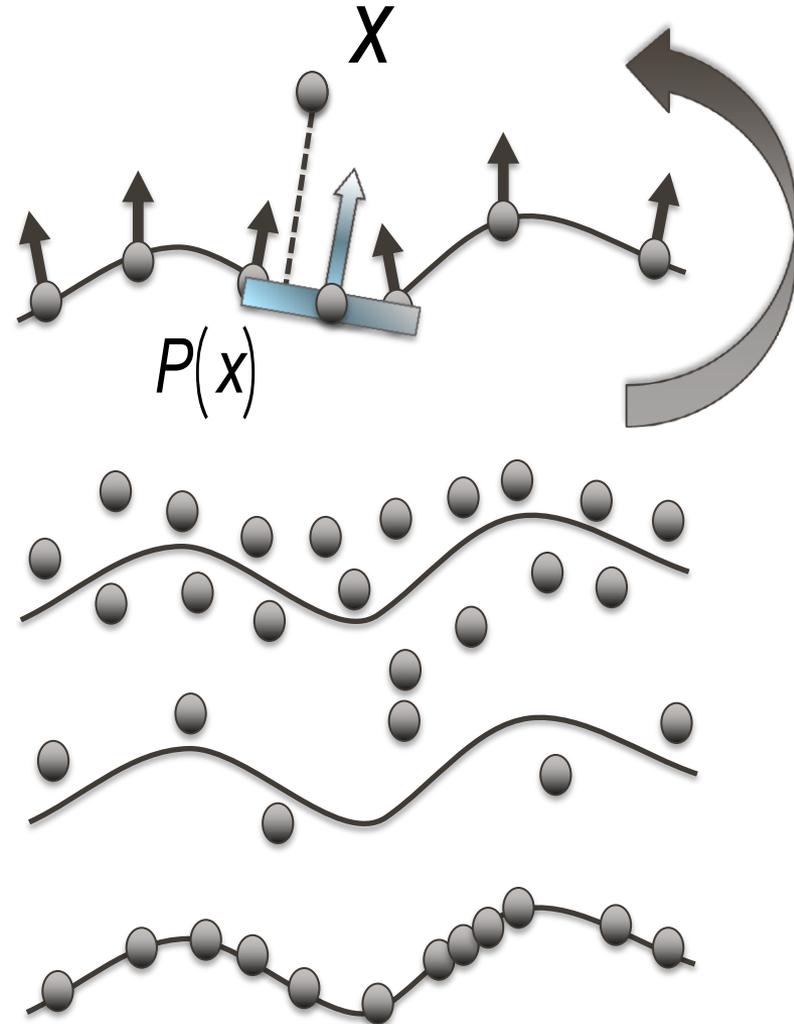
Itérations



Raffiner

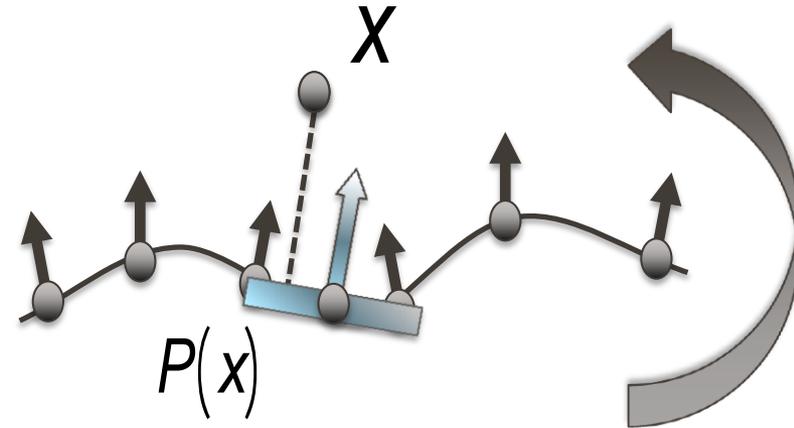
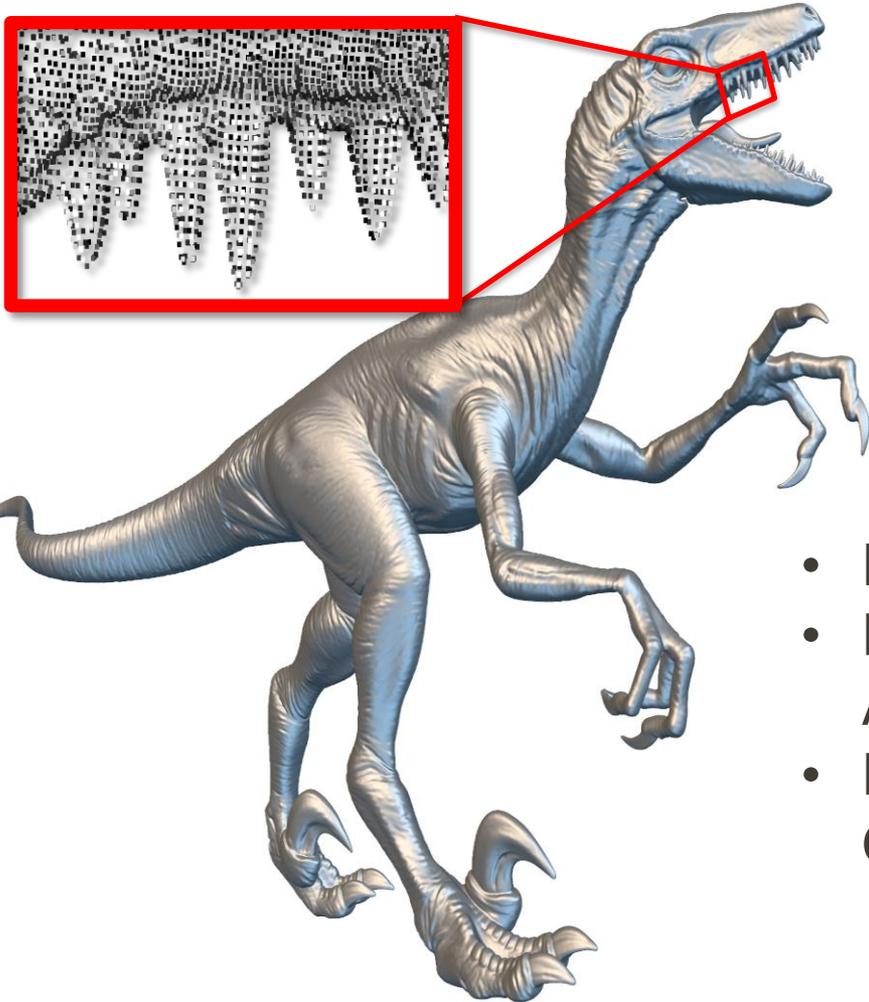
Simplifier

Ré-échantillonner



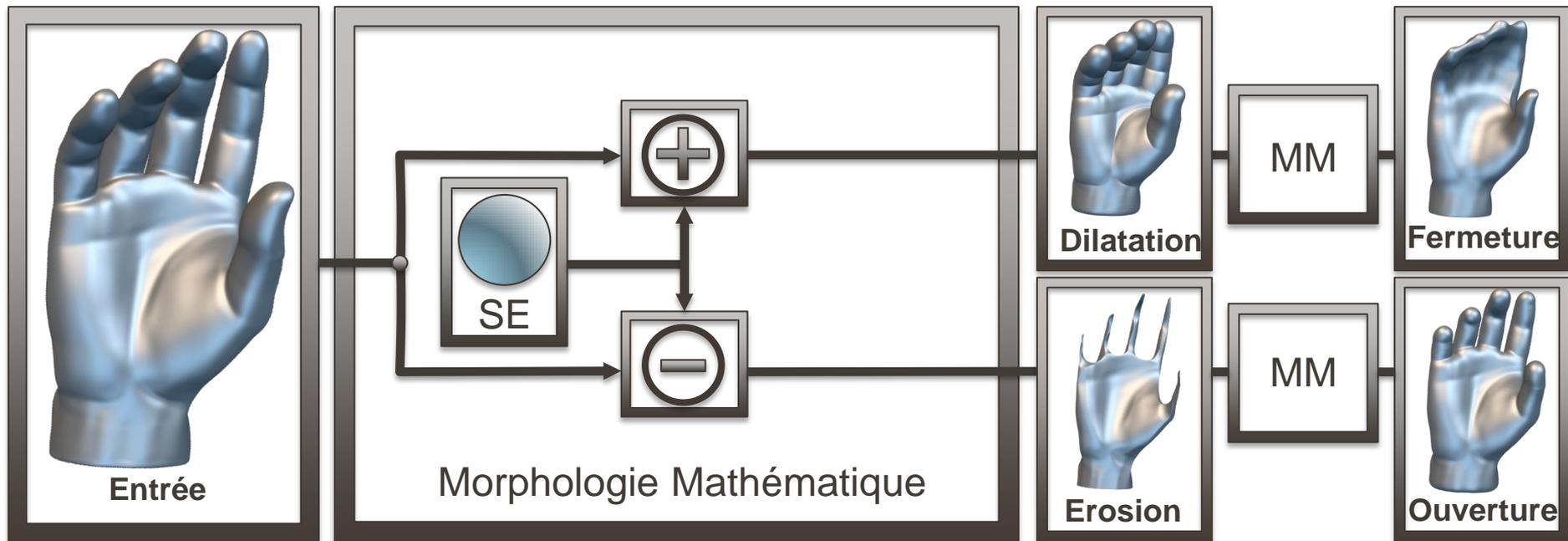
Surfaces de points (PSS)

Itérations

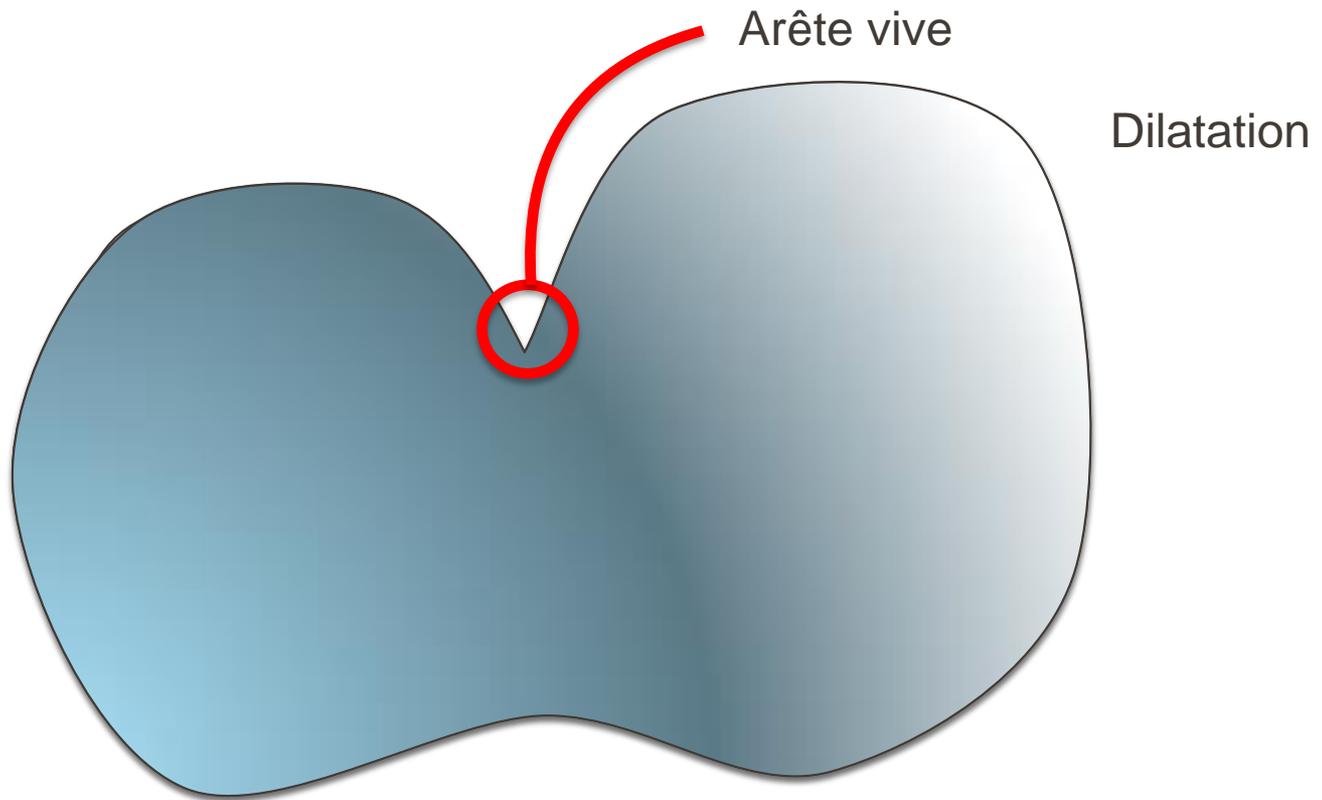


- PSS Simple : [Amenta and Kil 2004]
- PSS hermitienne : [Alexa and Adamson 2009]
- PSS algébrique : [Guennebaud and Gross 2007]

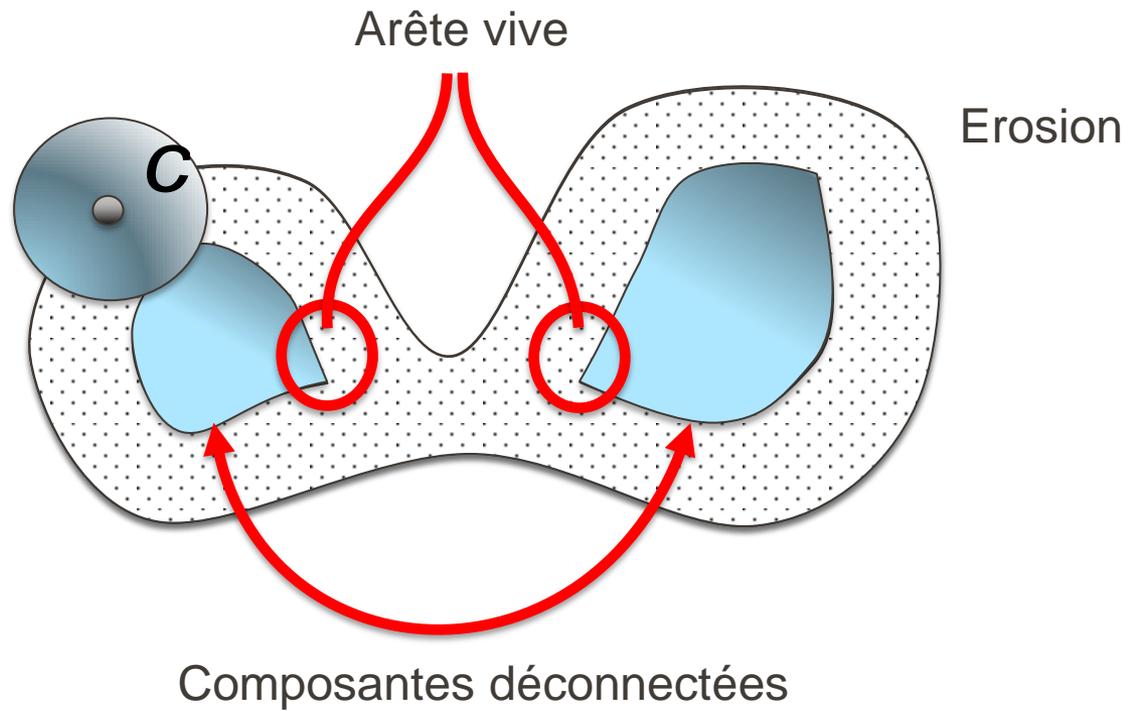
Morphologie mathématique



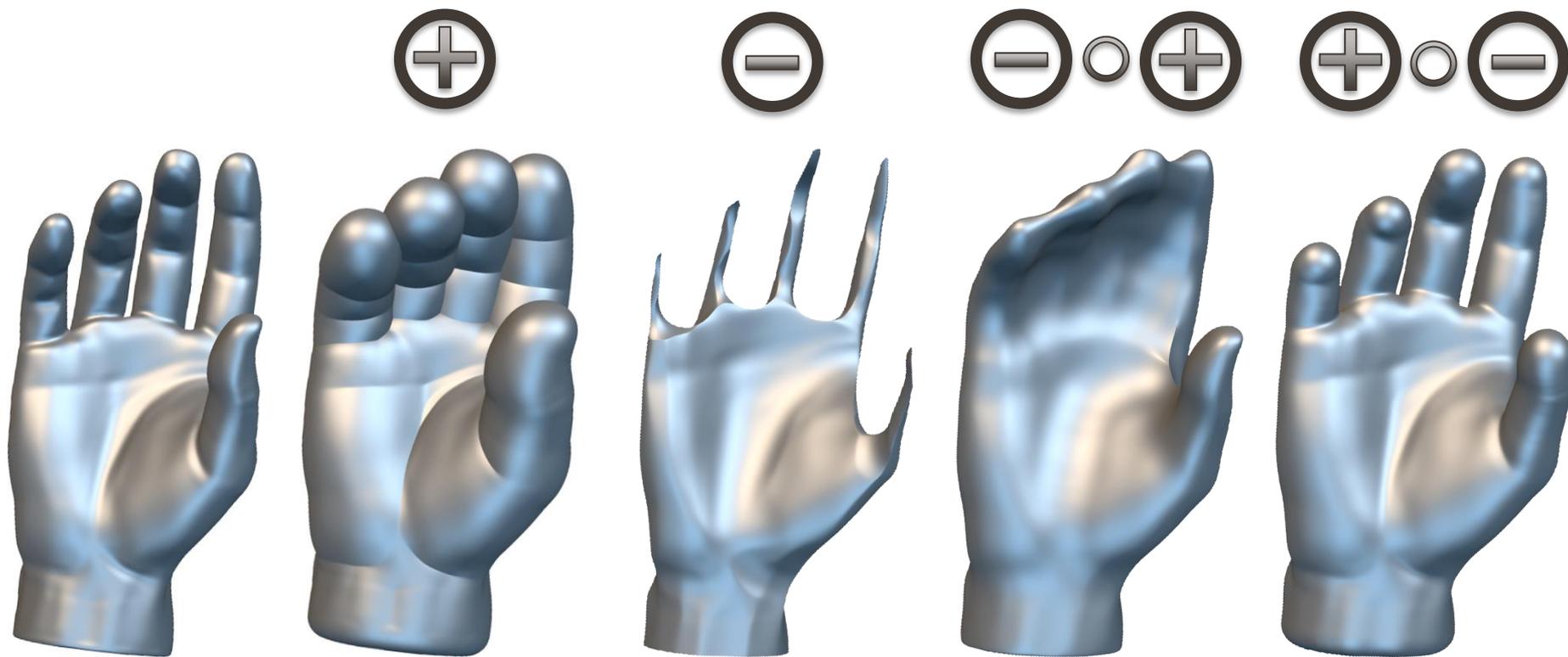
Dilatation



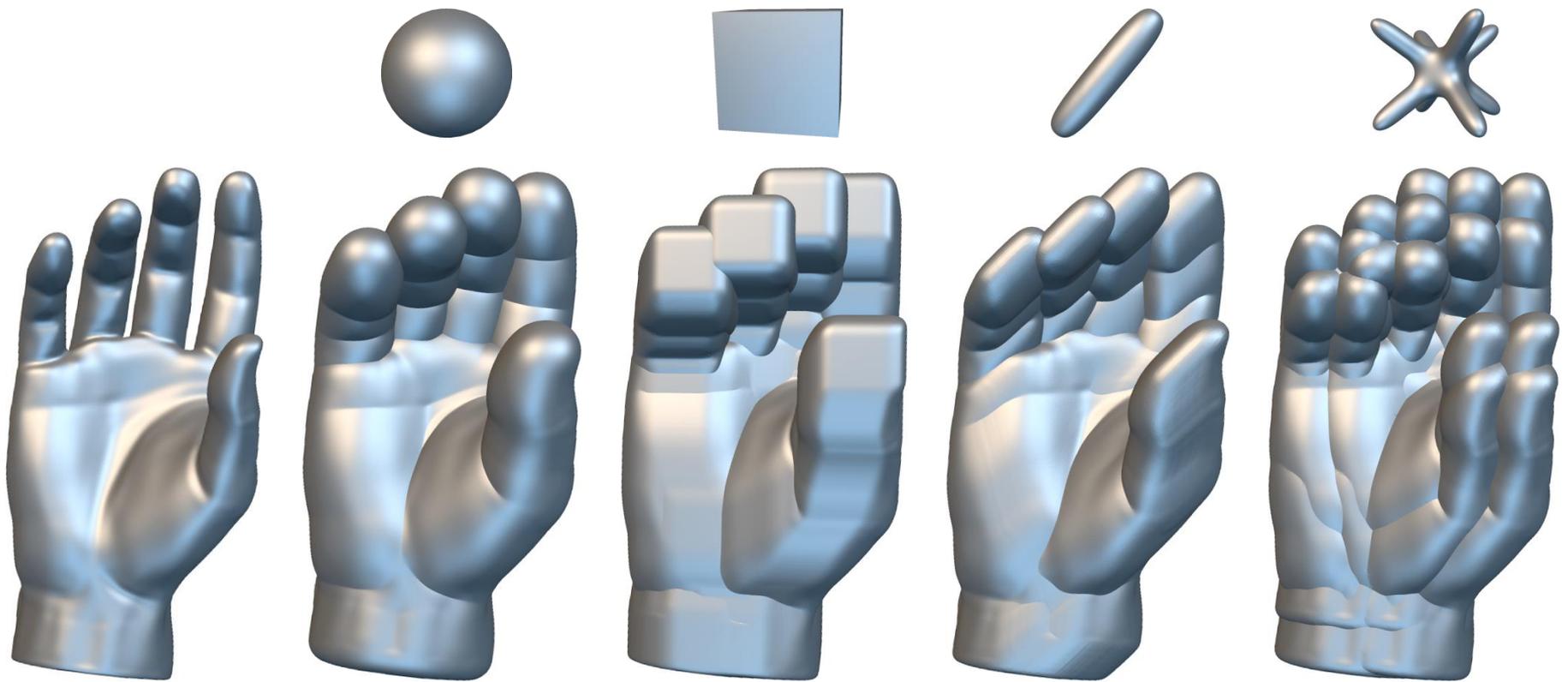
Erosion



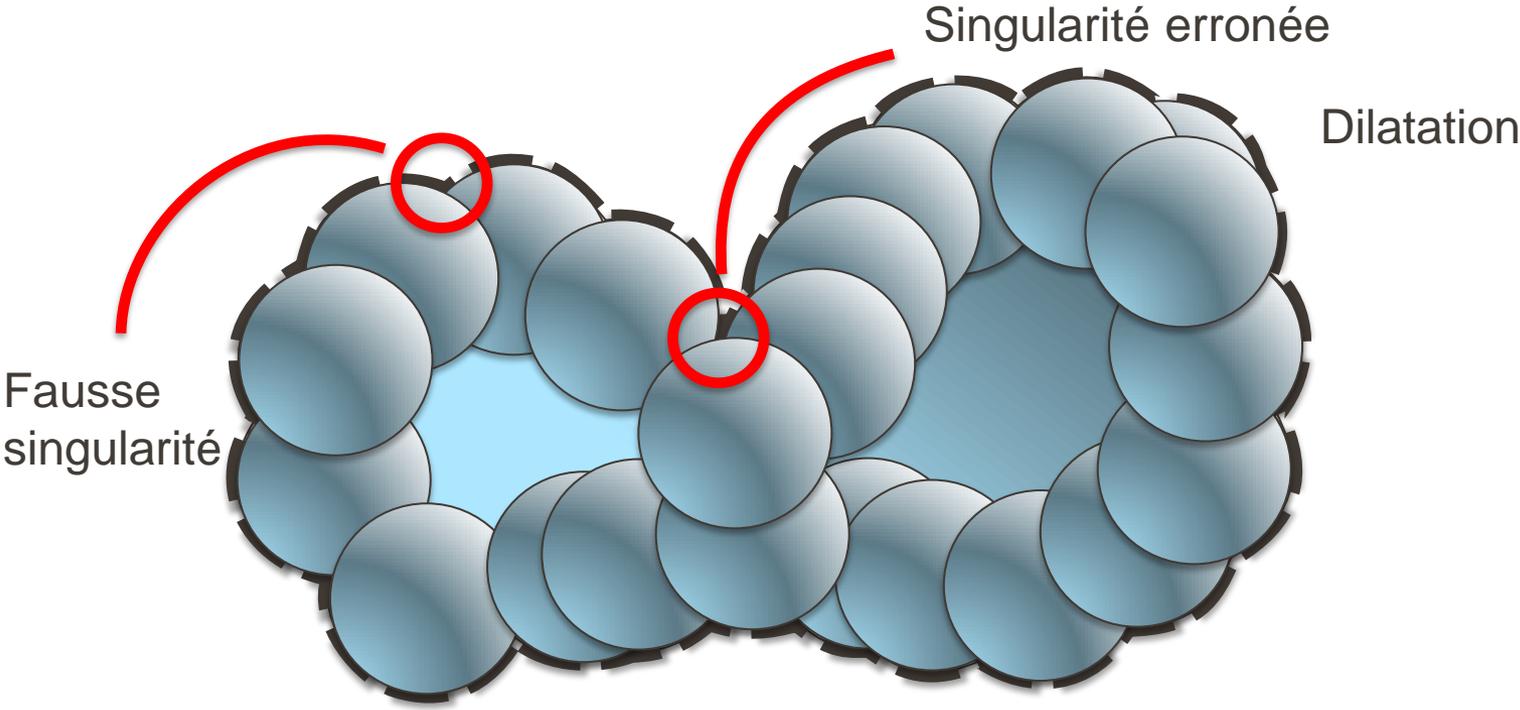
Exemple



Example

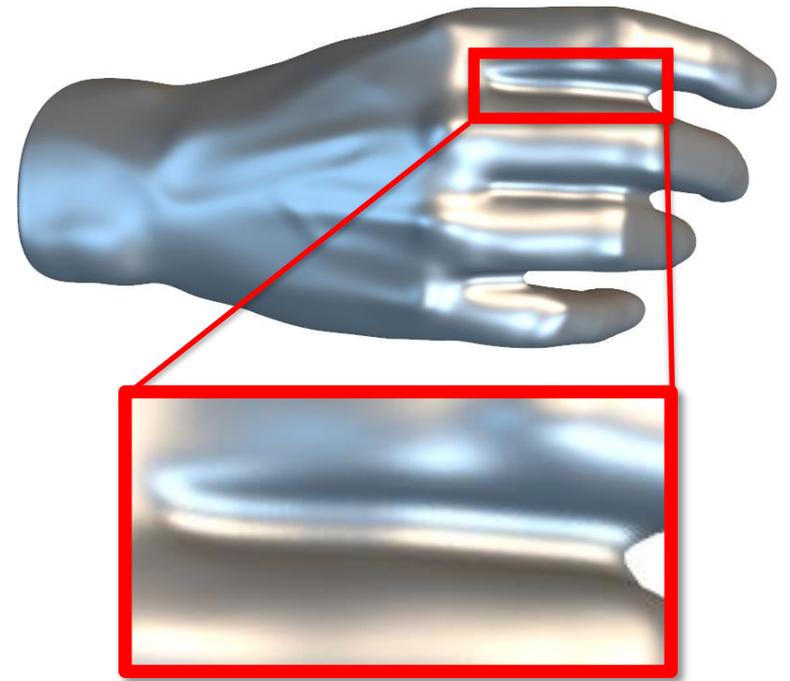
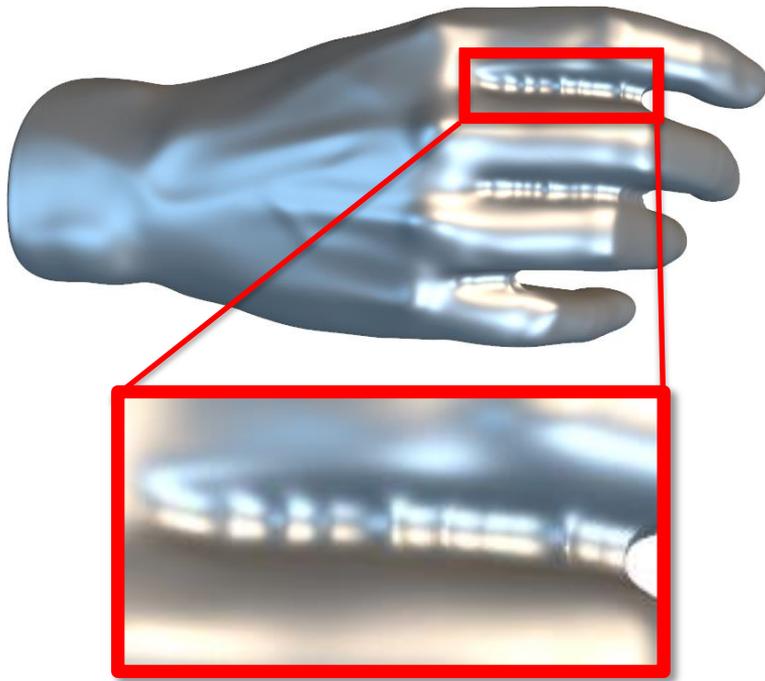


Evaluation par somme explicite

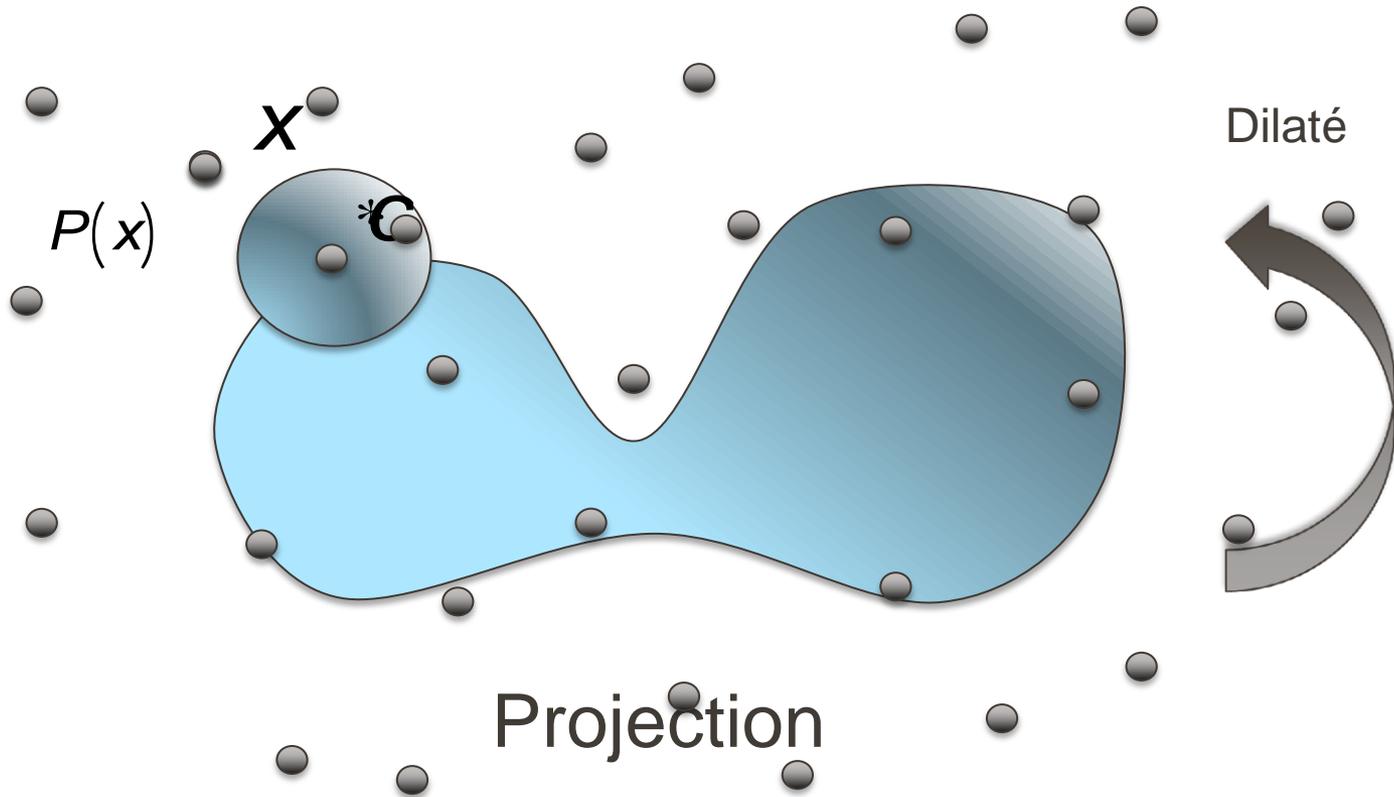


Ne passe pas à l'échelle

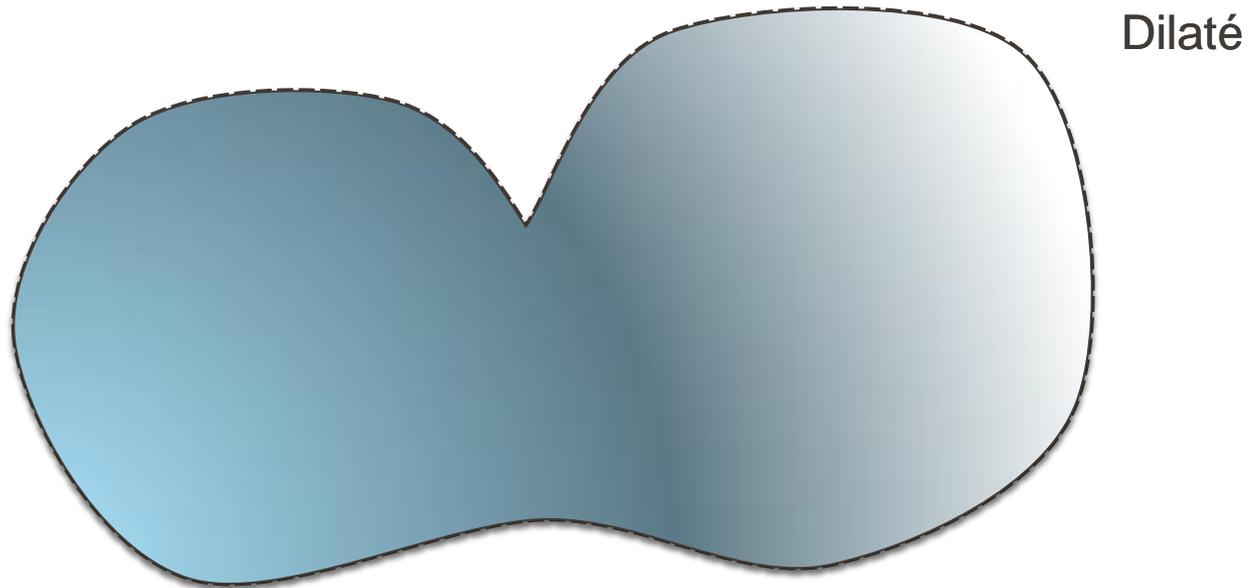
Erreur de reconstruction



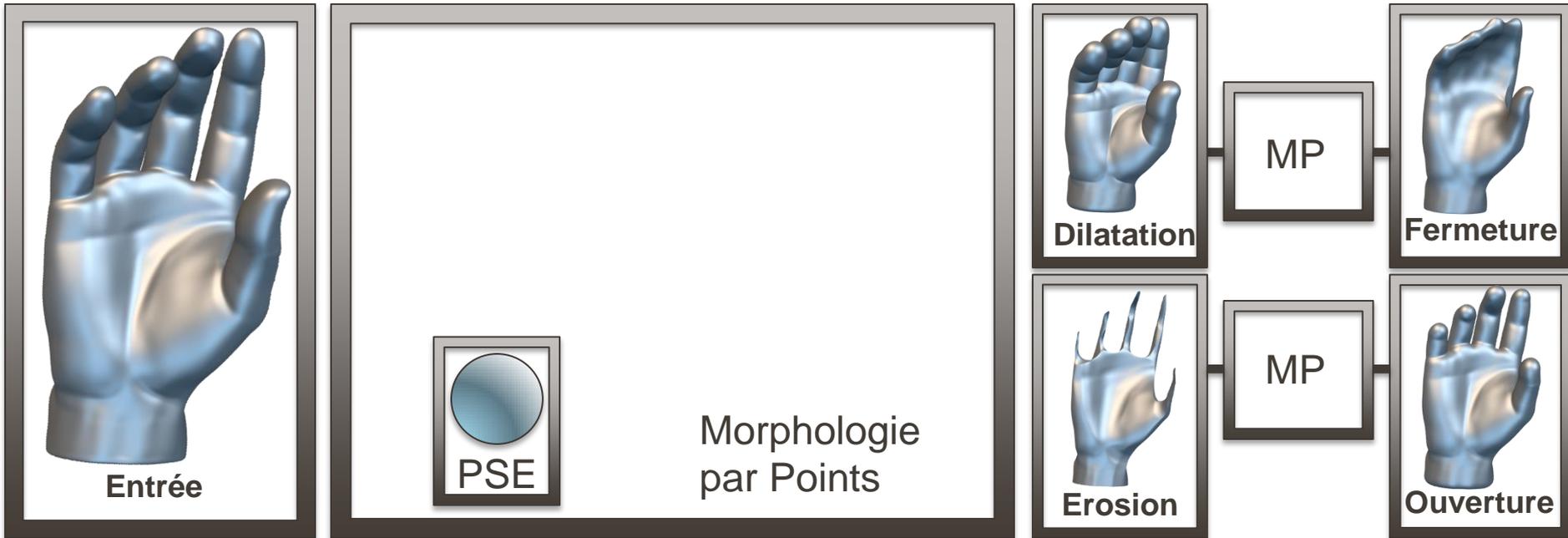
Morphologie projective



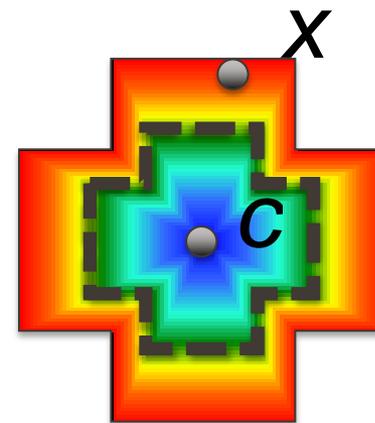
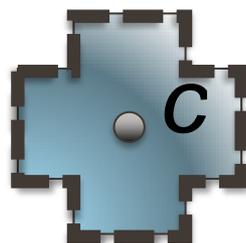
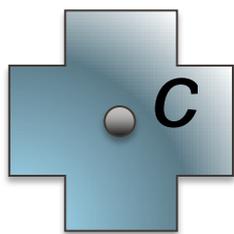
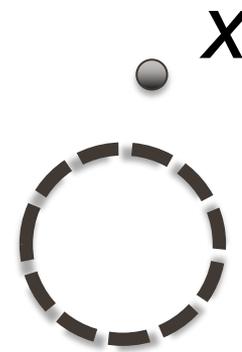
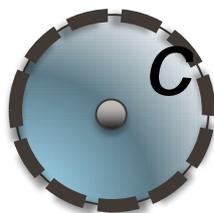
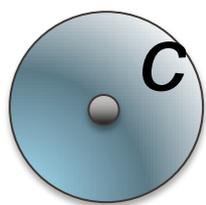
Morphologie projective



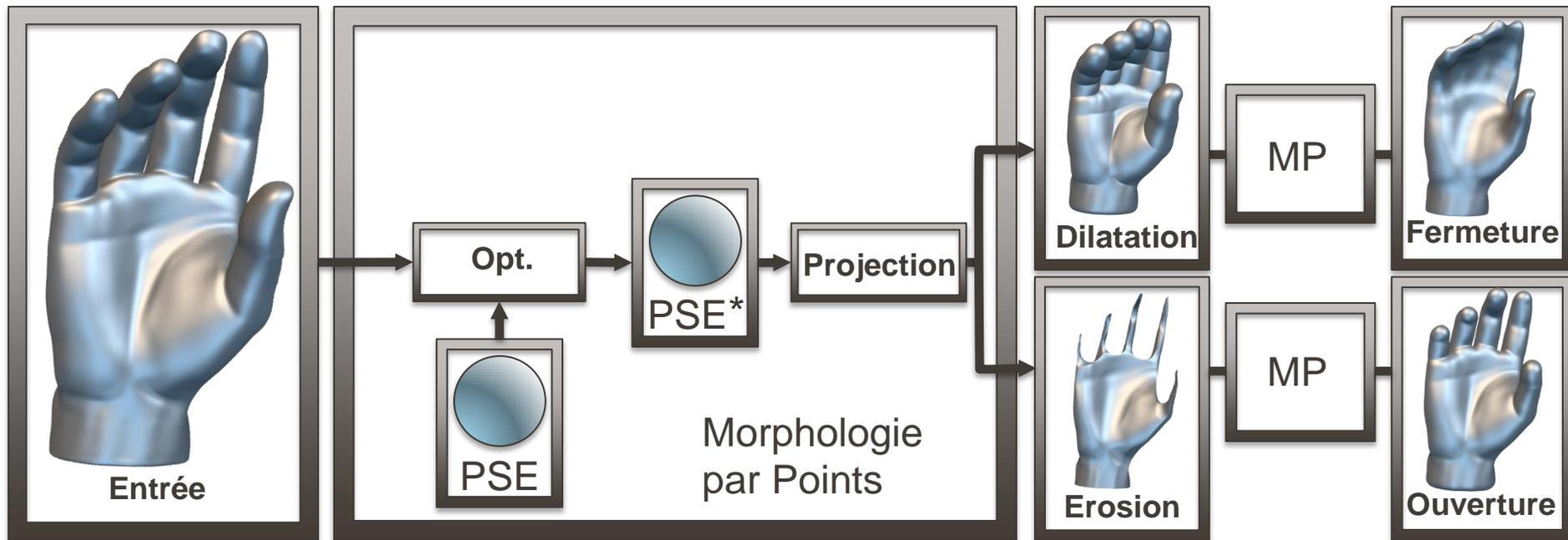
Morphologie par points



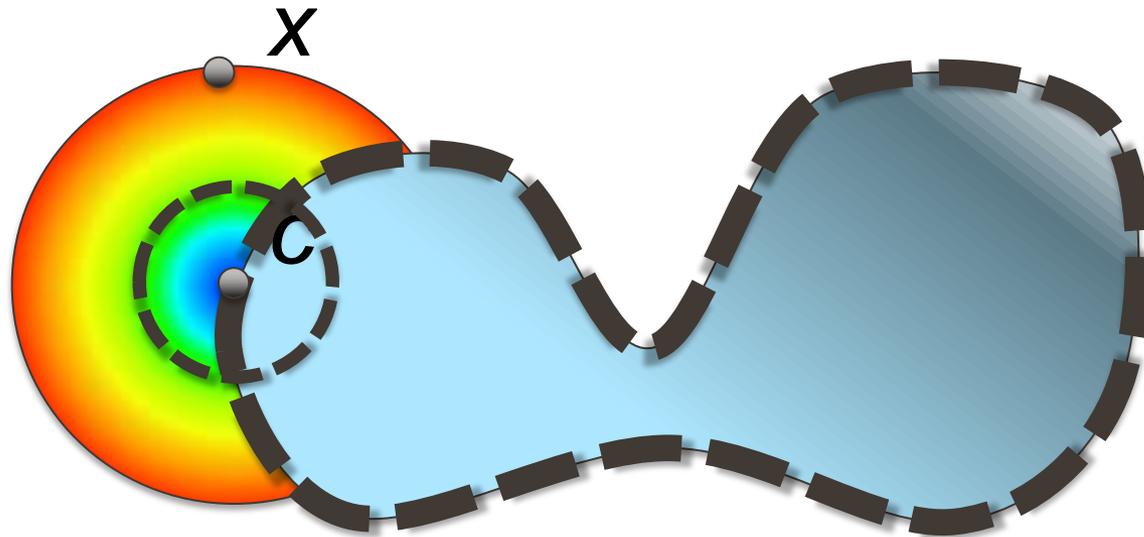
Élément structurant par point



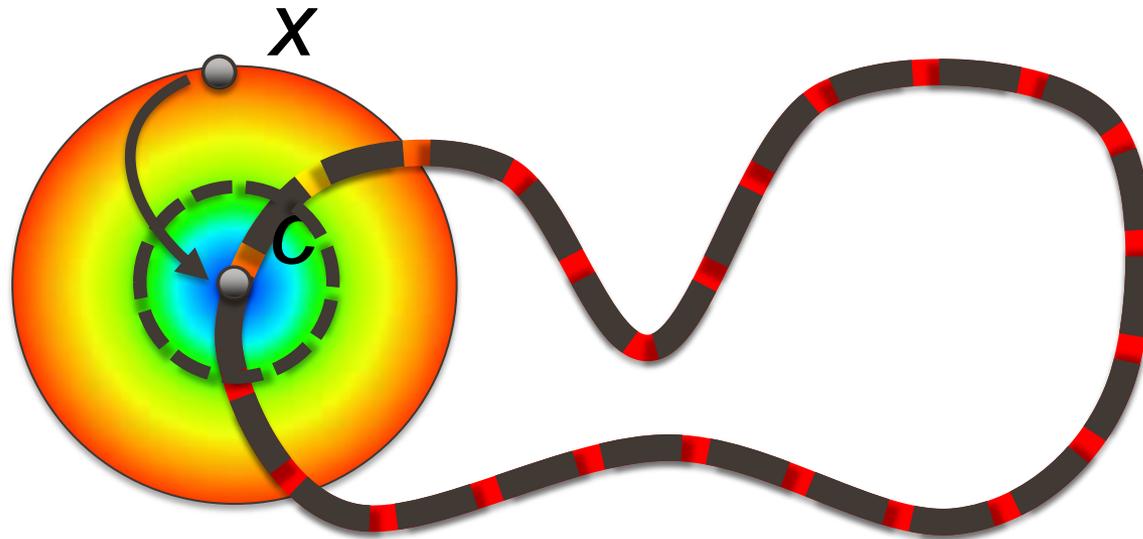
Morphologie par points



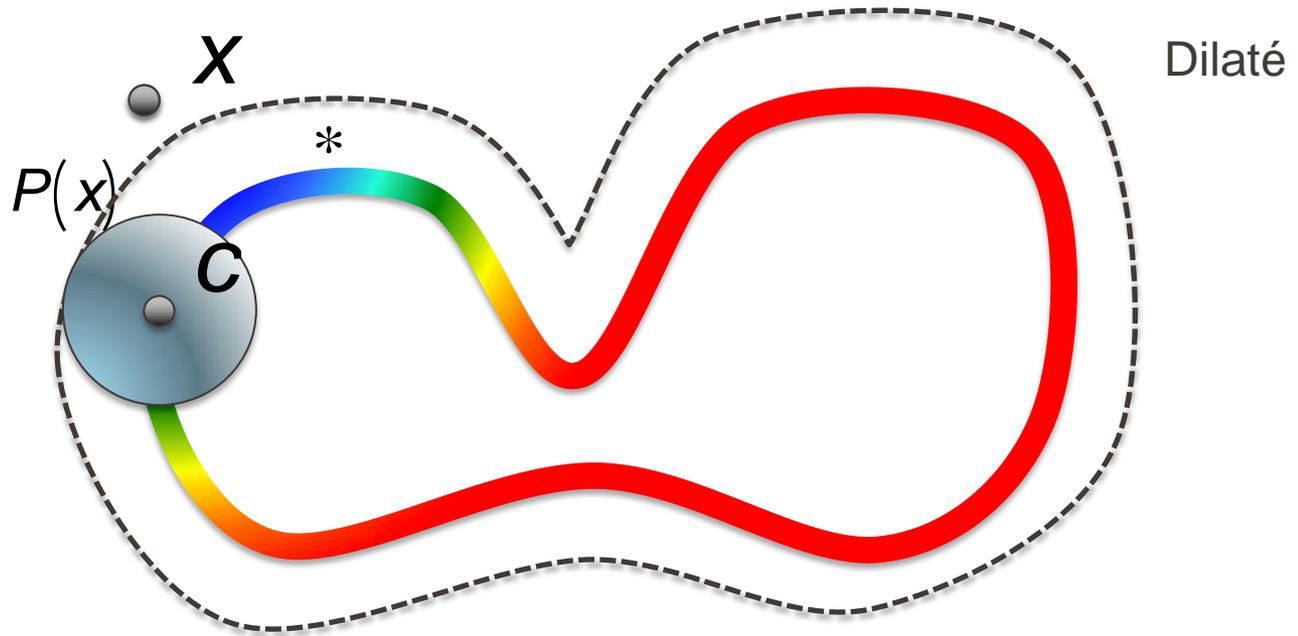
Optimisation



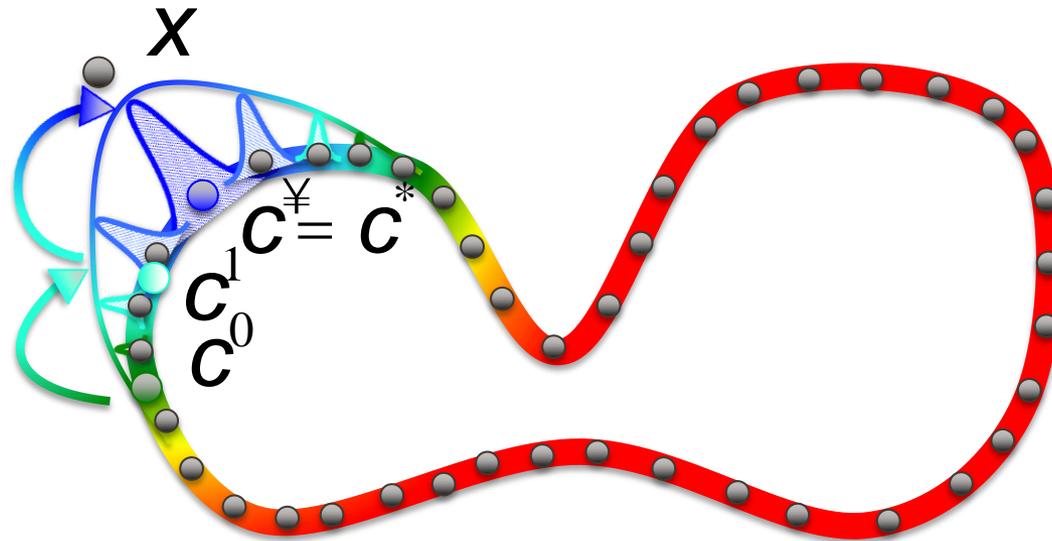
Optimisation



Optimisation

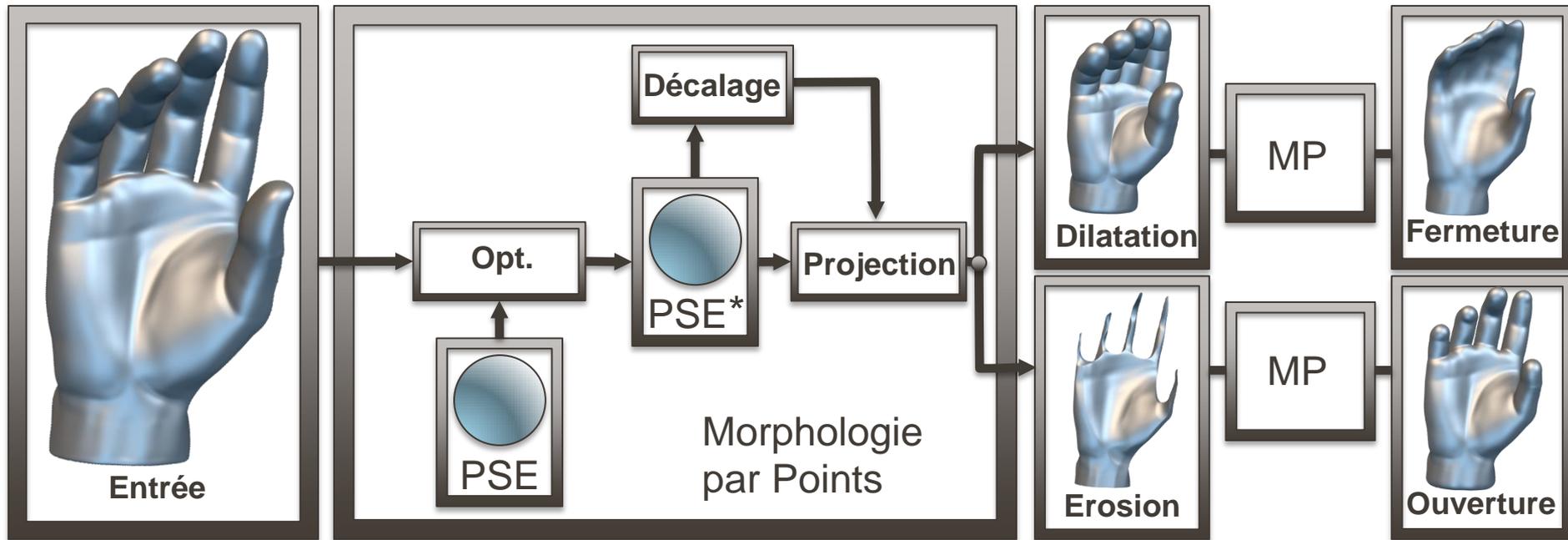


Optimisation par points

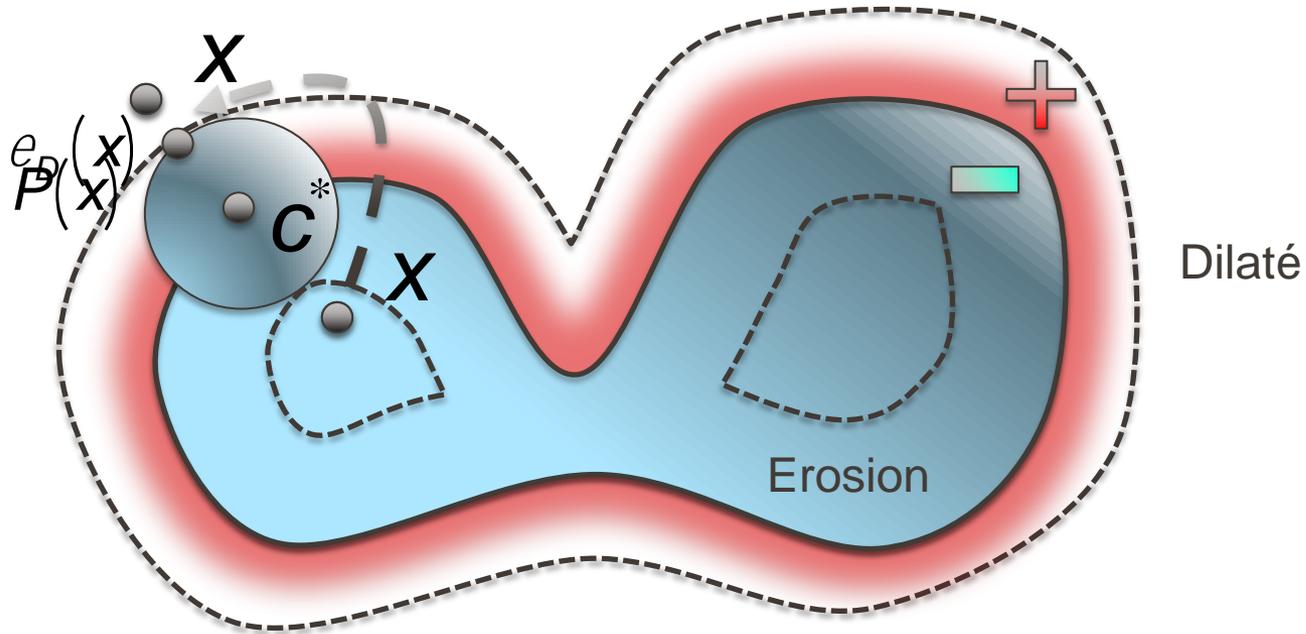


Mean Shift [Cheng 1995]

Morphologie par points

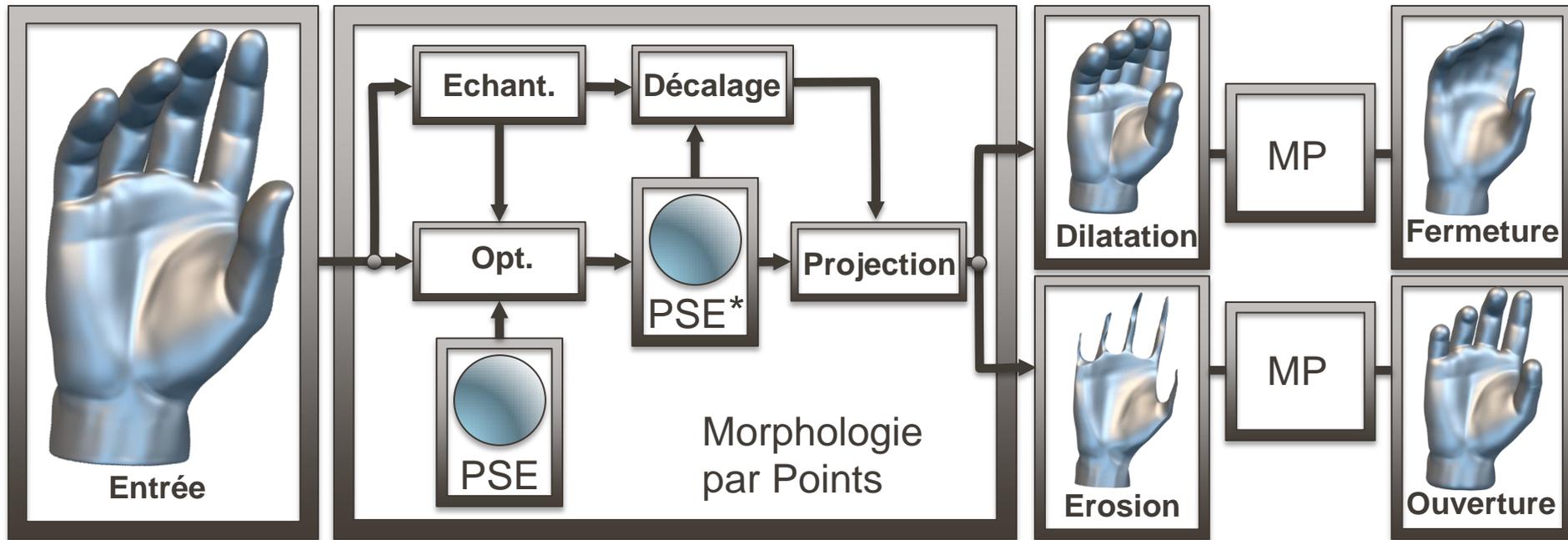


Décalage

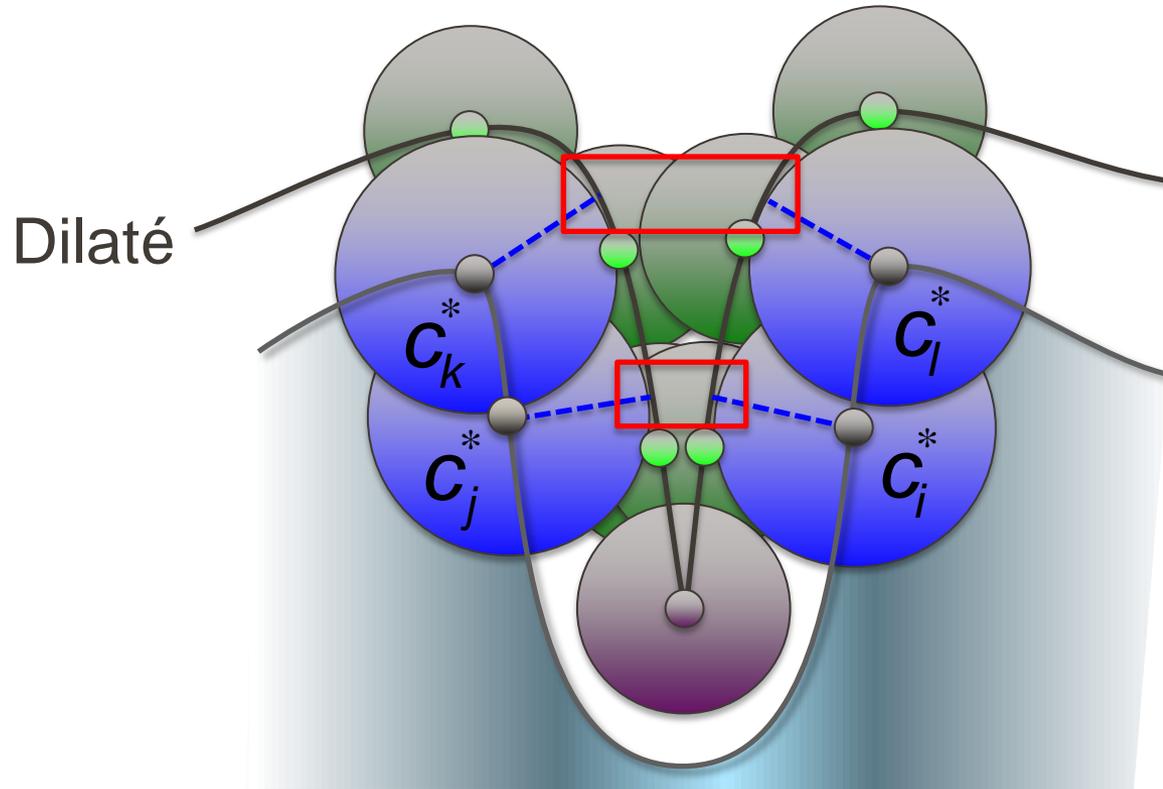


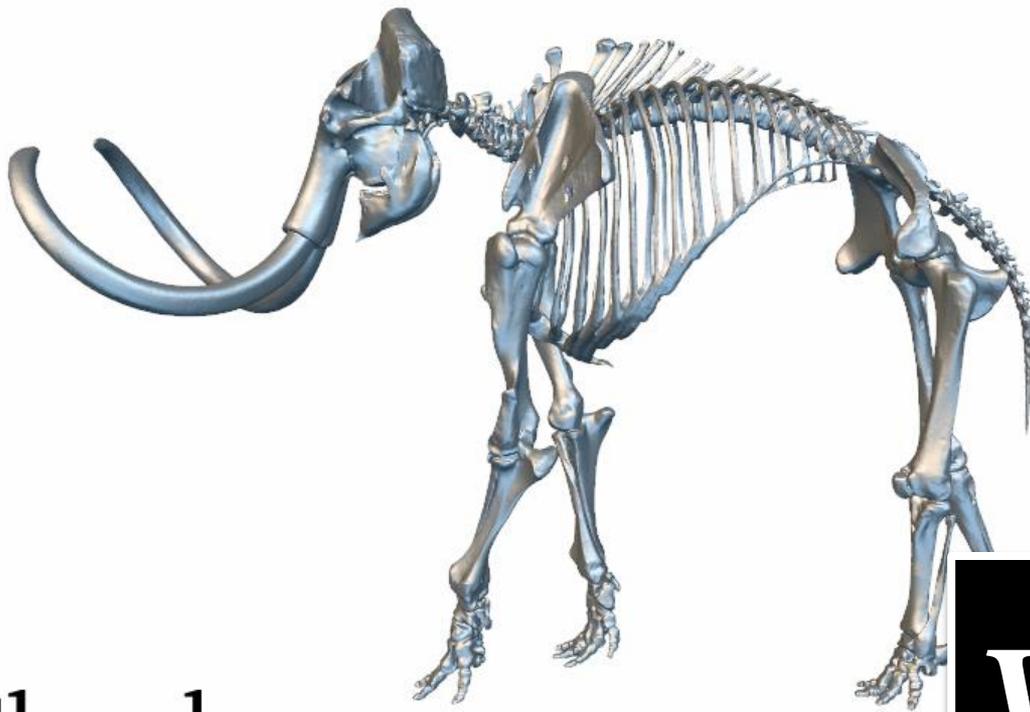
Indicateur *intérieur/extérieur* des surfaces de points [Amenta and Kil 2004]

Morphologie par points



Morpho-échantillonneur

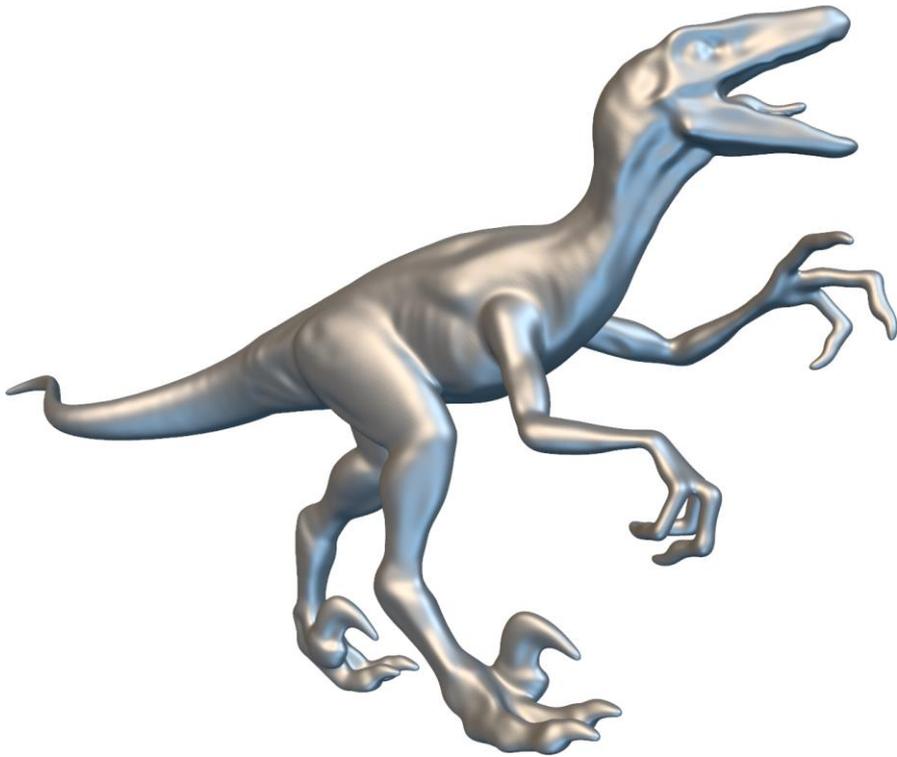




Input
Point Cloud

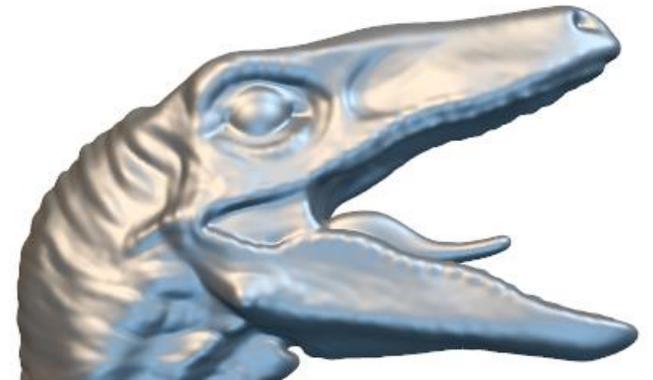
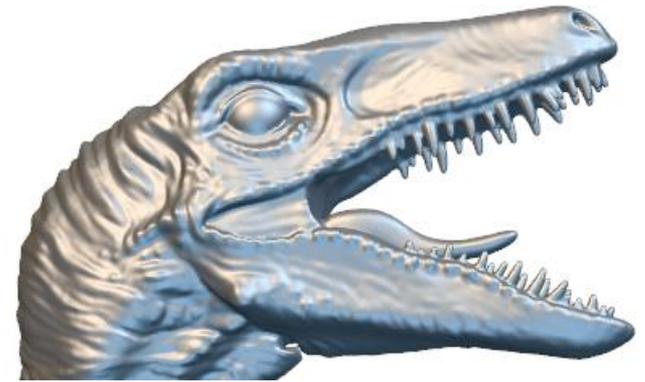
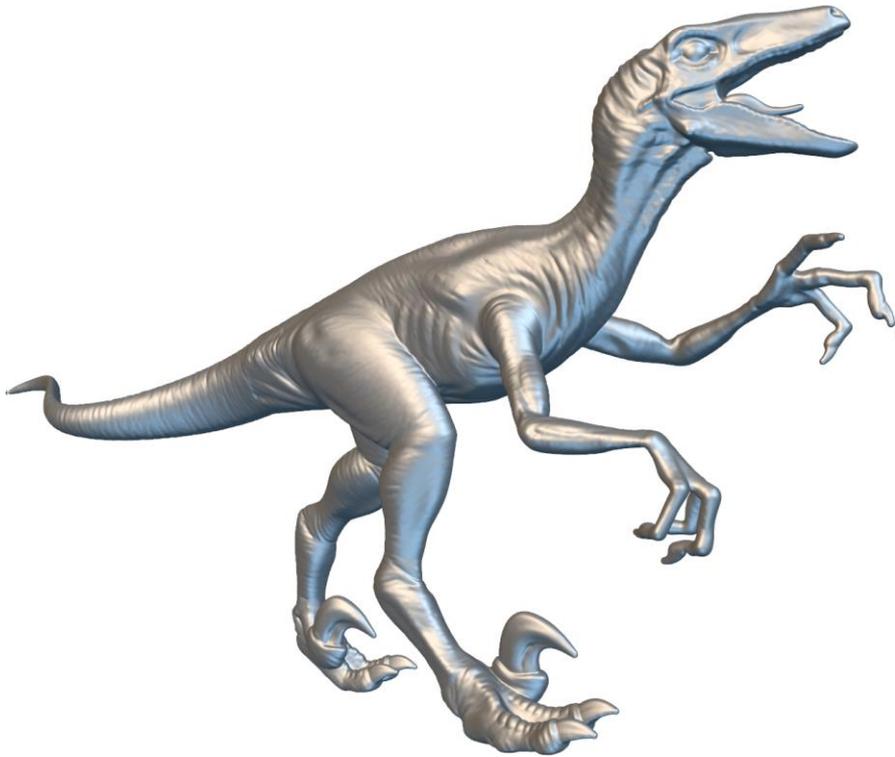


Application au filtrage de forme



PSS algébrique : [Guennebaud and Gross 2007]

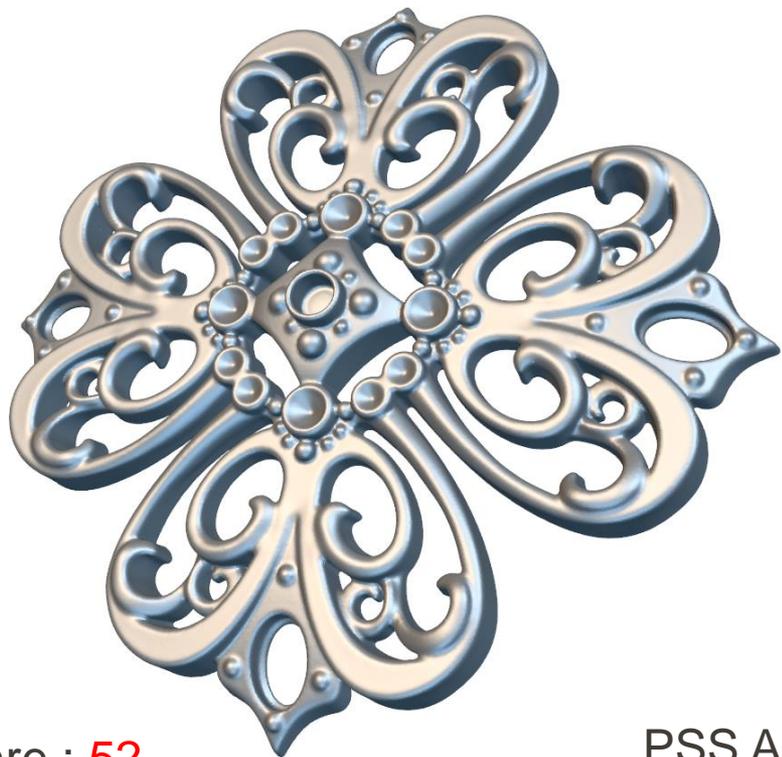
Application au filtrage de forme



Morphologie par points

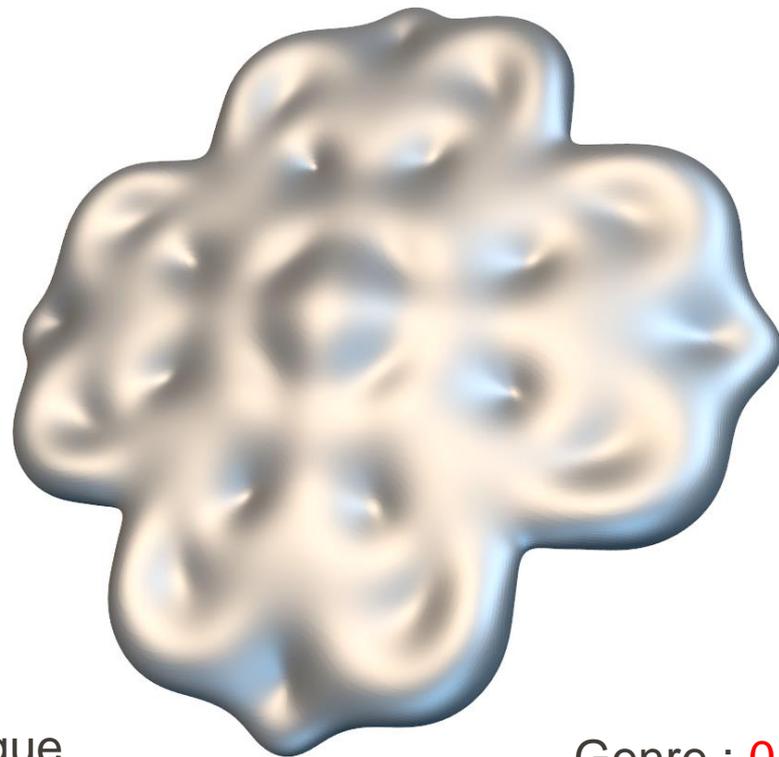


Application à la simplification topologique



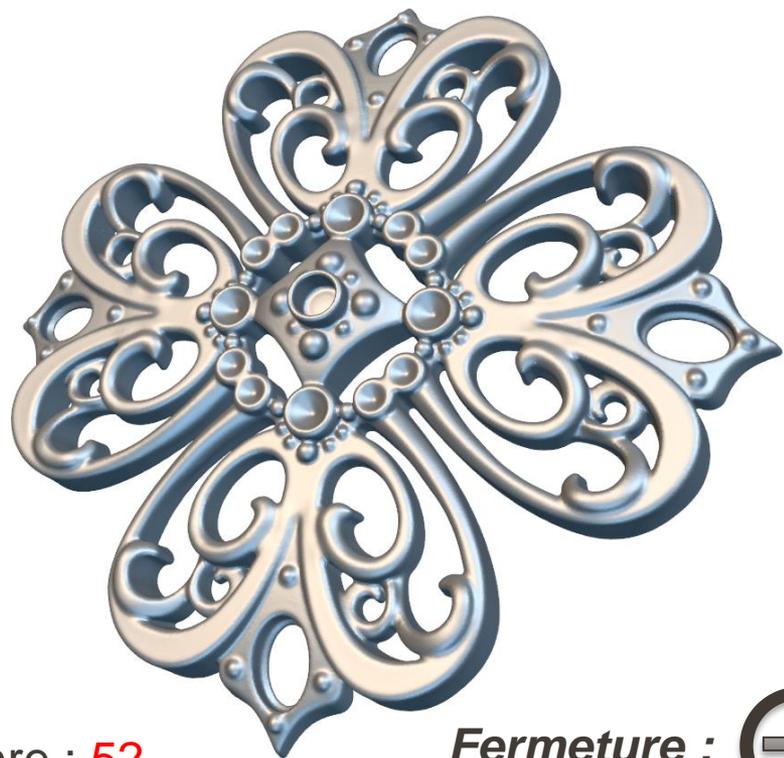
Genre : 52

PSS Algébrique



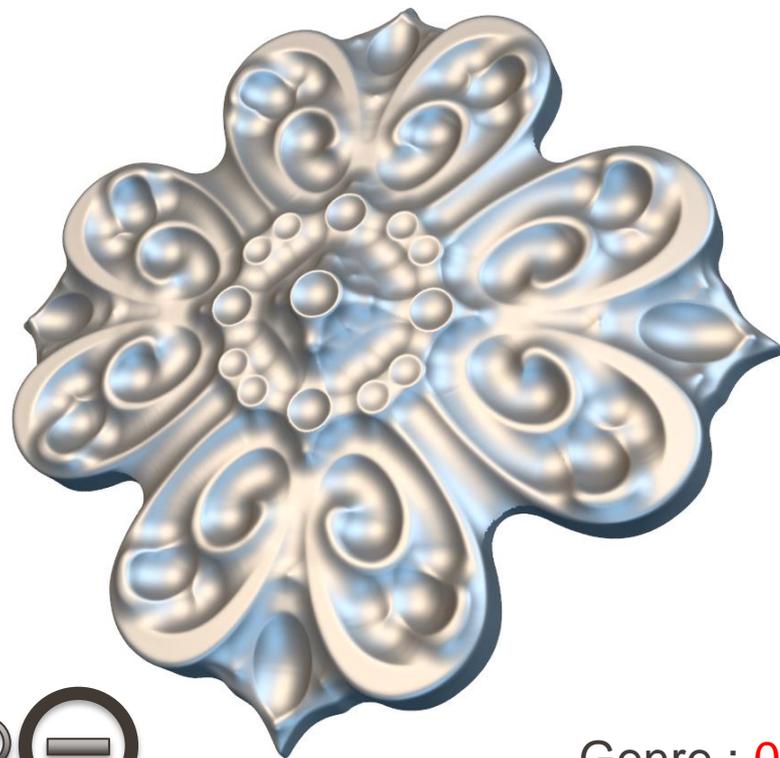
Genre : 0

Application à la simplification topologique



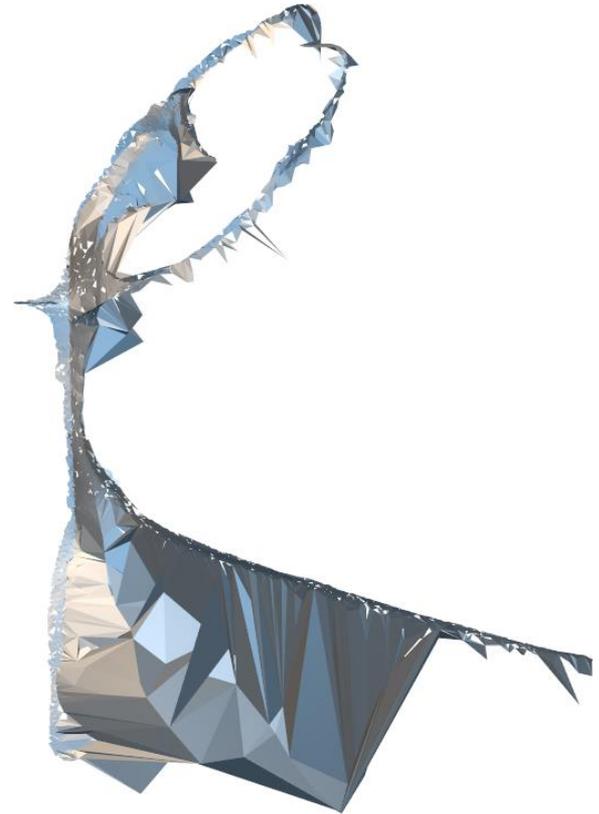
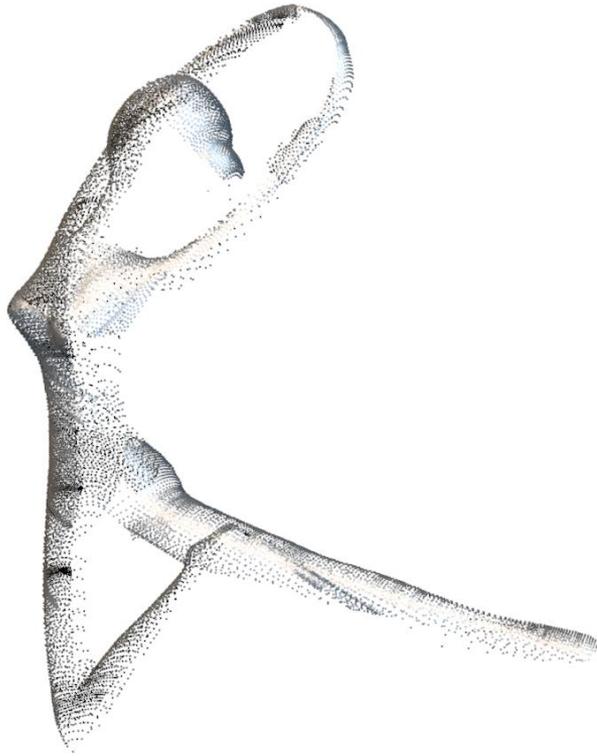
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Fermeture :



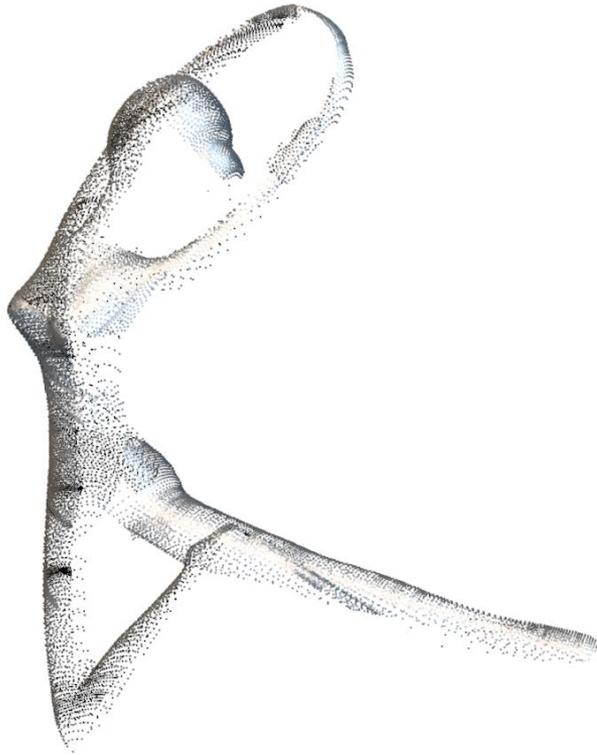
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Axe médian



Power Crust [Amenta and al. 2001]

Axe médian

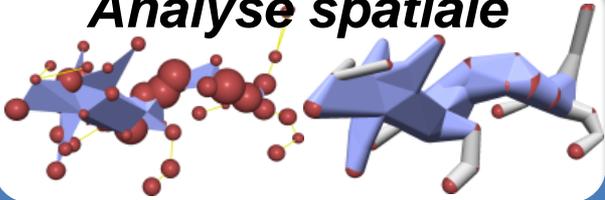


Morphologie par points

CONCLUSION

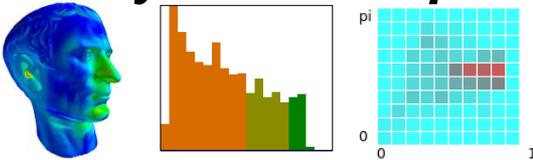
De l'analyse à la modélisation

Analyse spatiale



- **Sphere-Meshes**
 - un petit ensemble de « nombres » pour la modélisation spatiale d'une forme
 - *contrôle de déformation*

Analyse statistique



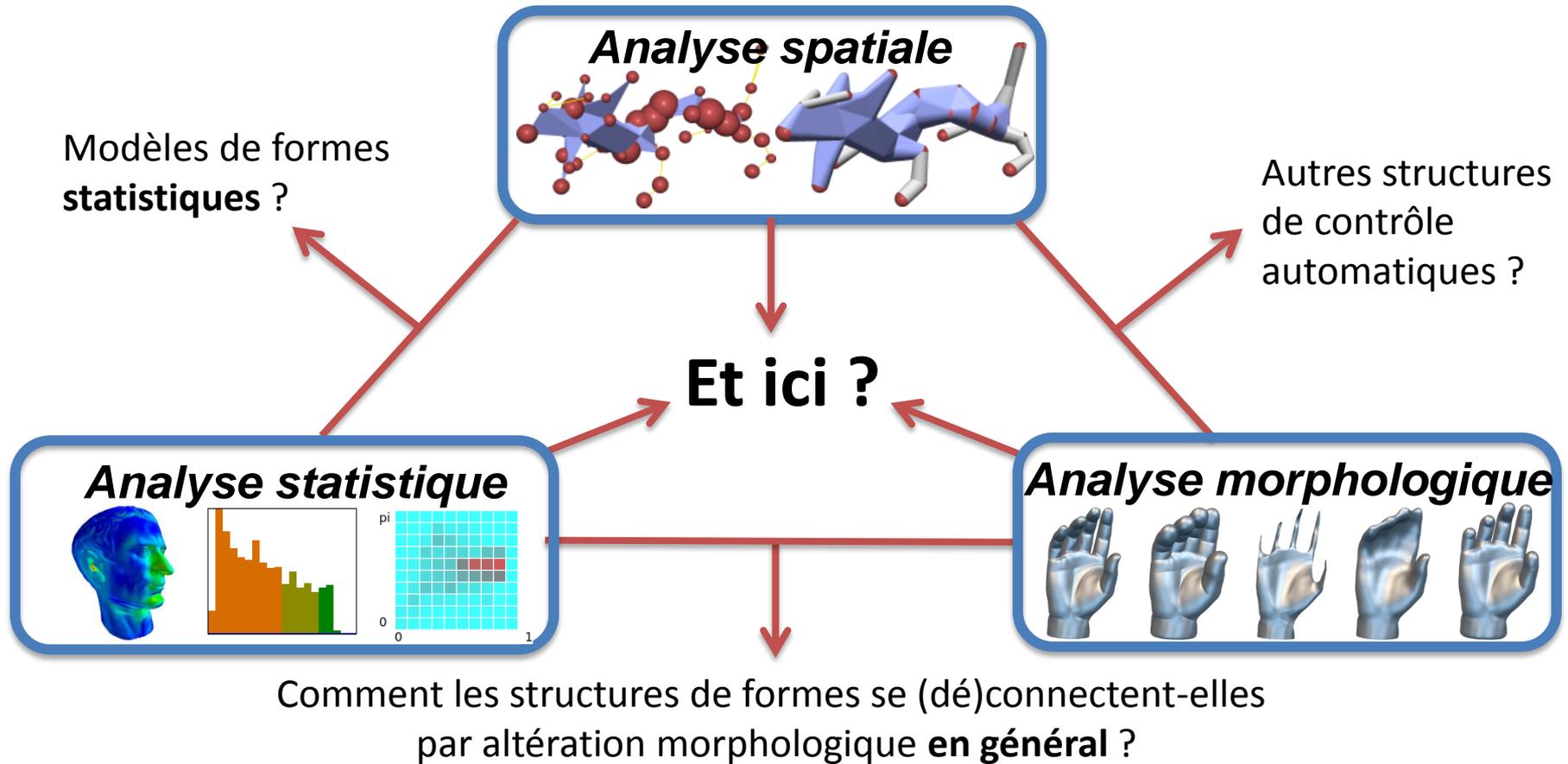
- **SimSelect**
 - modélisation **collaborative** des données visuelles
 - *reconnaissance de formes interactive*

Analyse morphologique



- **Morphologie par Points**
 - morphologie **projective** sans maillage
 - *filtrage géométrique et topologique*

Perspectives



Doctorants :

Stéphane Calderon, Emilie Guy & Jean-Marc Thiery

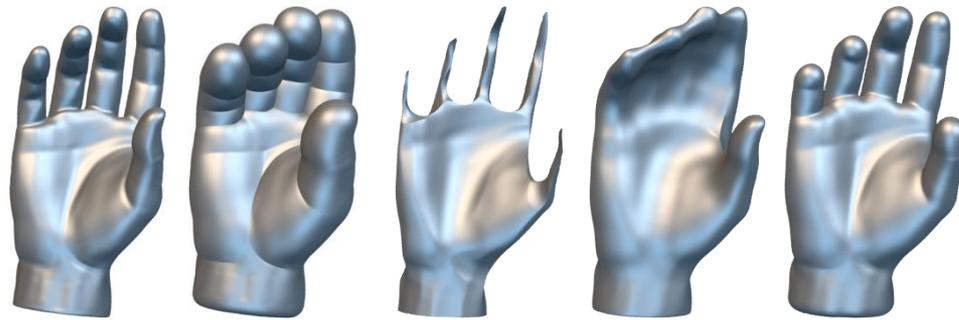
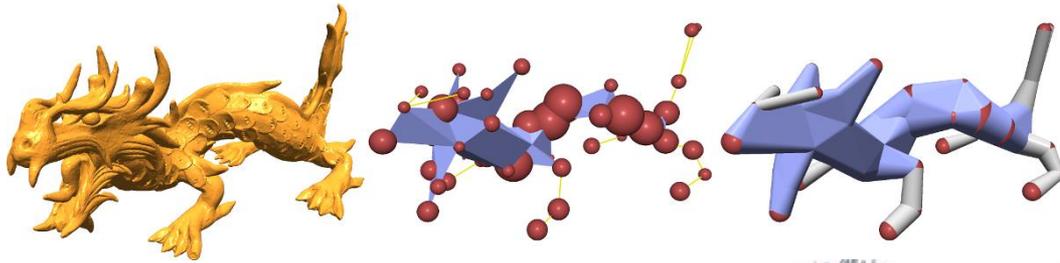
Publications :

Sphere-Meshes, SIGGRAPH Asia 2013

SimSelect, EUROGRAPHICS 2014

Point Morphology, SIGGRAPH 2014

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