Recovering Primitives in 3D CAD meshes

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C4W, Montpellier, France
LSIS, Arles, France

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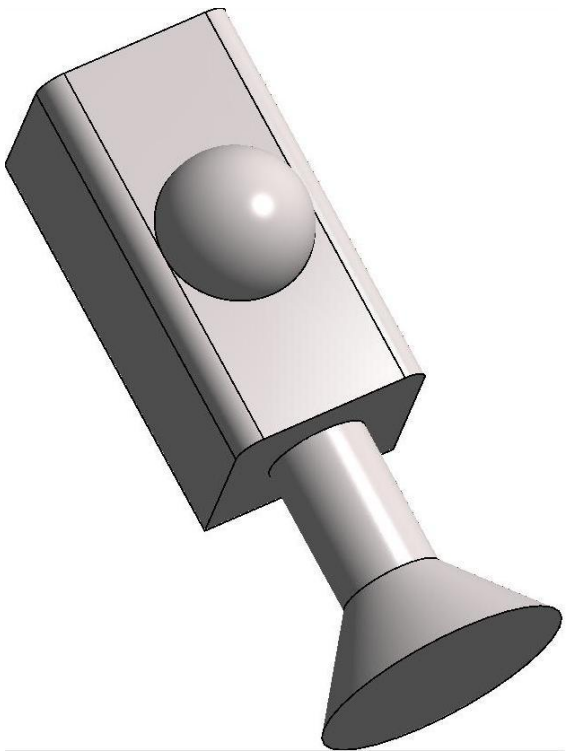
Réunion ICAR

Objective

In CAD an object is usually modeled by a structured combination of primitives



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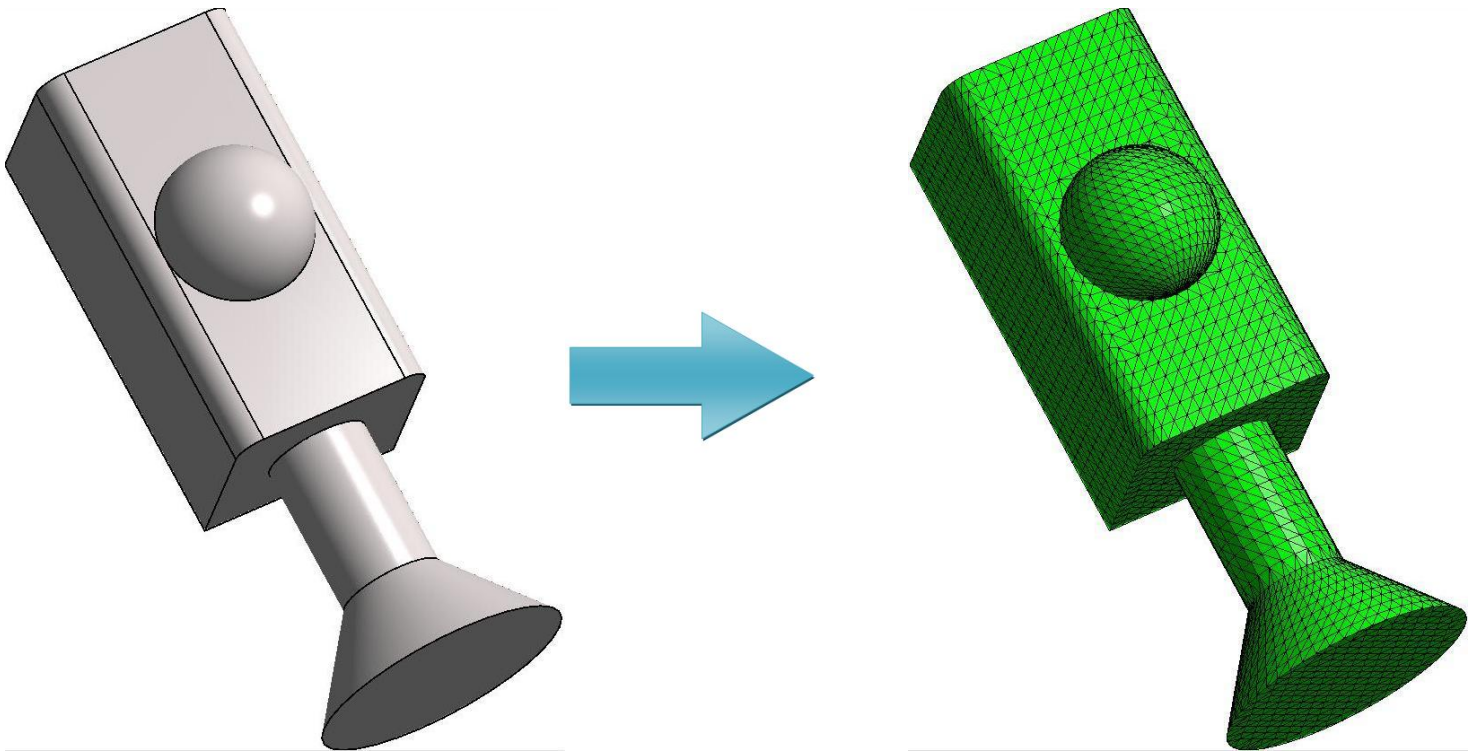

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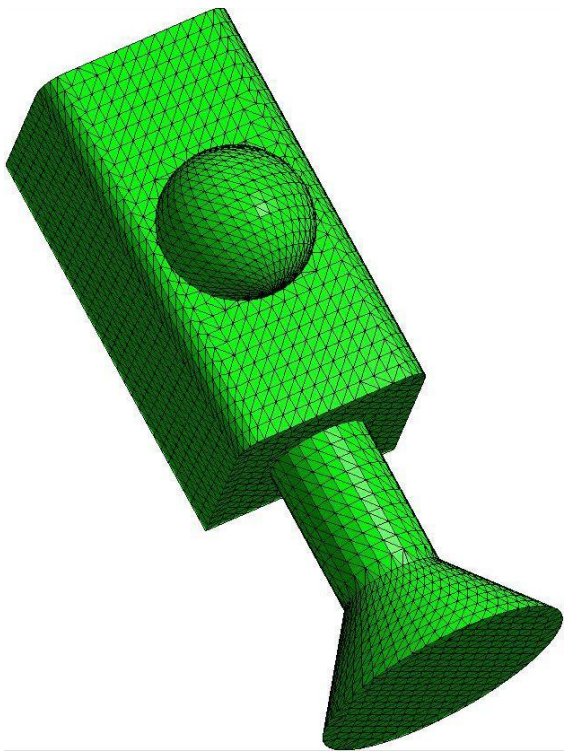

Objective

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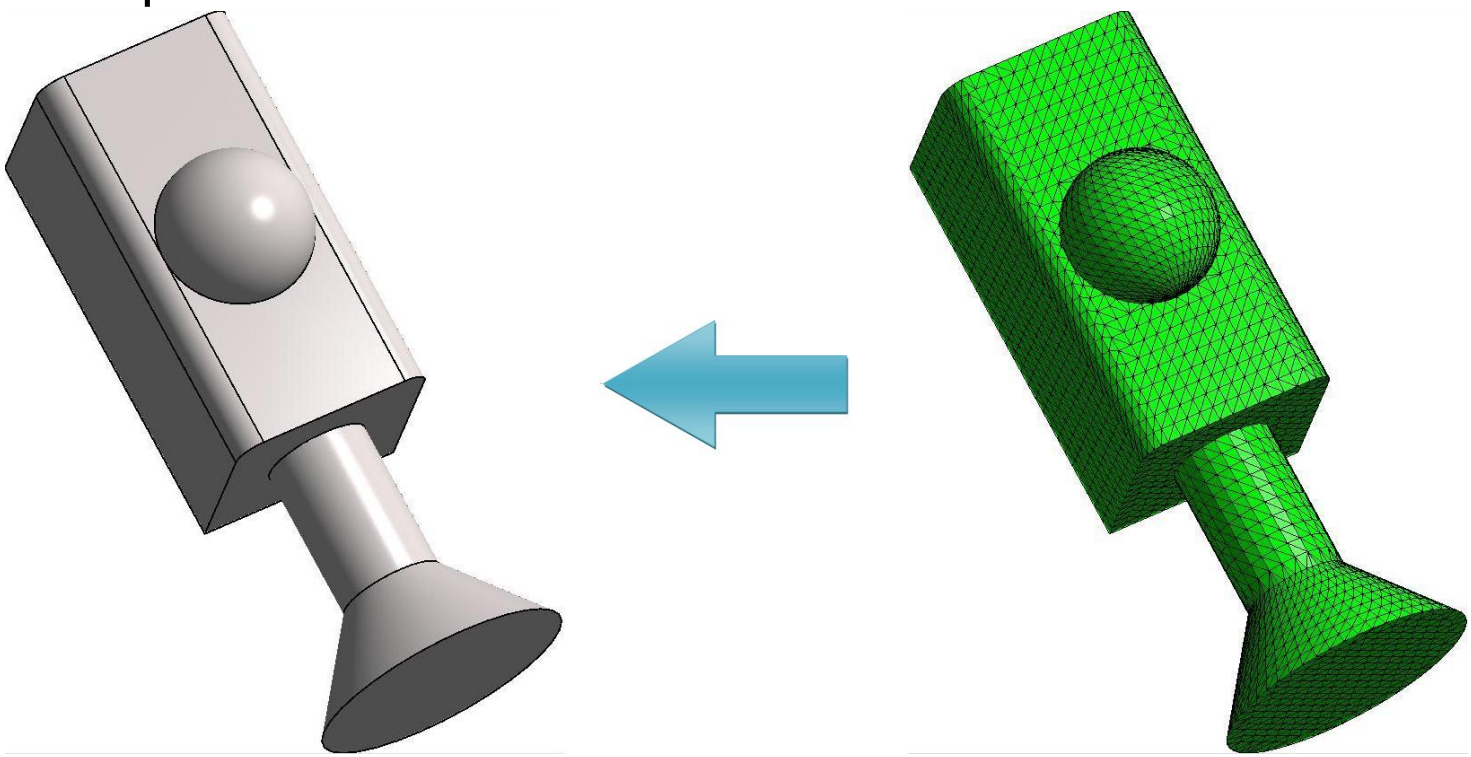
But to use, we often need to discretized it into a 3D mesh
And the initial model can be lost or not correspond anymore
So a primitive extraction algorithm is needed to reconstruct the initial representation



Previews

Benkõ *et al.*
Algorithms for reverse engineering boundary representation models
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Bohm *et al.*
Curvature based range image classification for object
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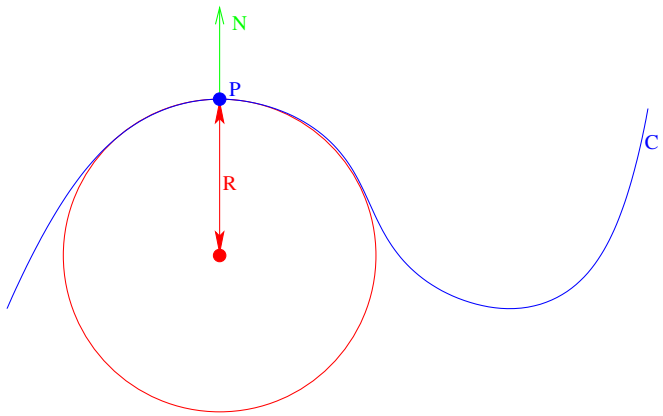
Same Process :

1. Segmentation
2. Classification
3. Fitting

Curvature 2D and 3D

Curvature 2D :



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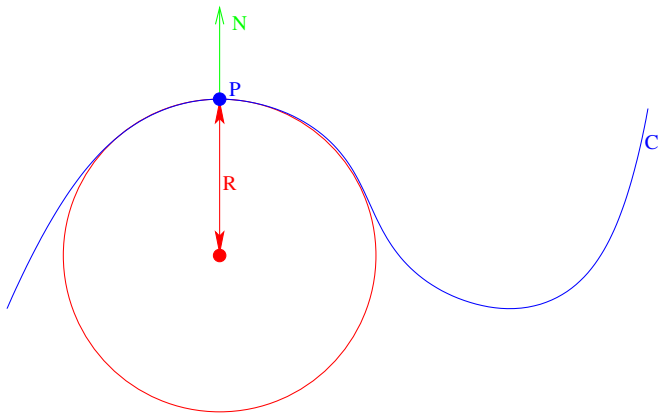

$$\Rightarrow K_p = \frac{1}{R}$$

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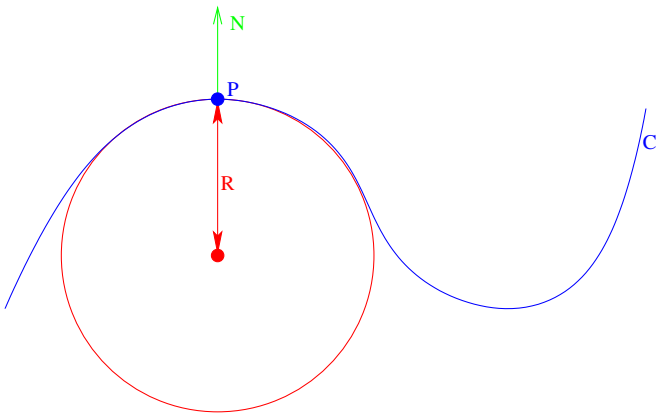

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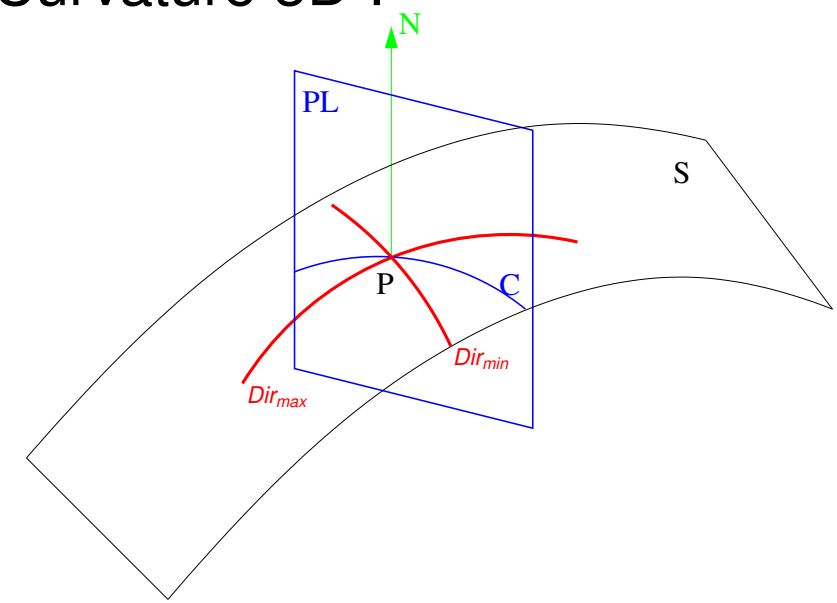

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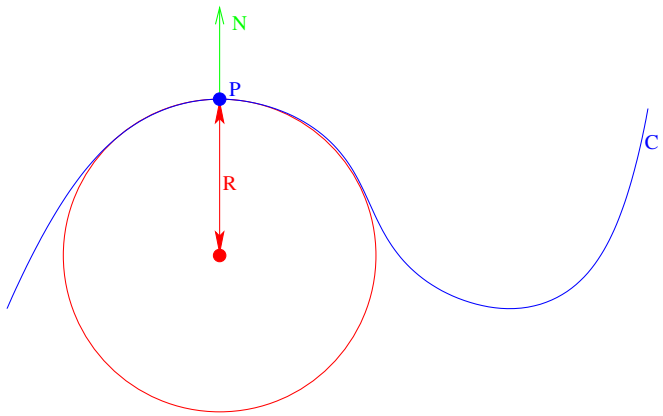

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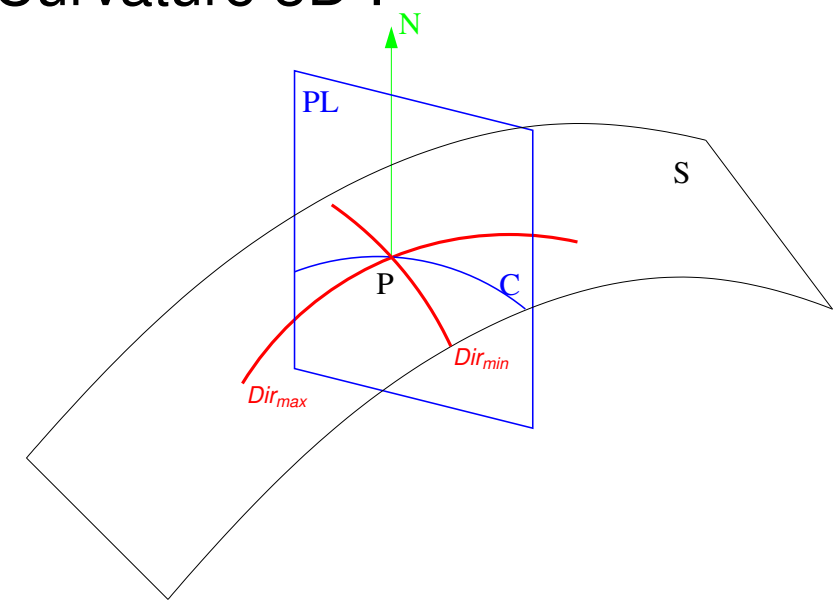

- 2 Principal Curvatures (k_{max} et k_{min})
- 2 Principal Directions (Dir_{max} et Dir_{min})
- Normal

Primitive curvature features

The points contained in Plane, Sphere, Cone or Cylinder have specific features on curvature :

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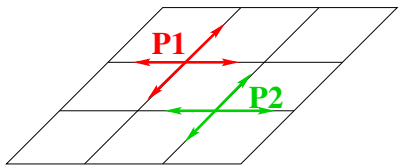

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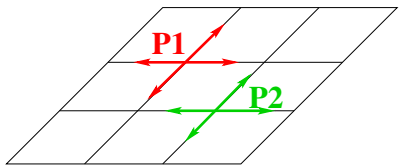

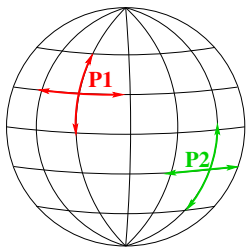

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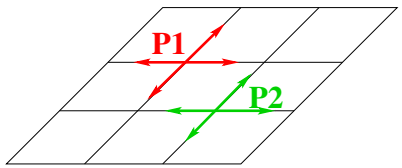

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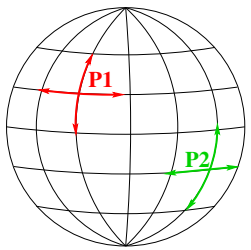
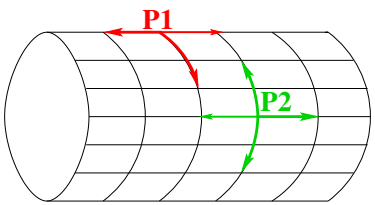


- Cylinder $\Rightarrow k_{min} = 0$ et $k_{max} = \frac{1}{\text{rCy}}$



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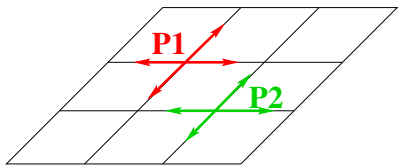

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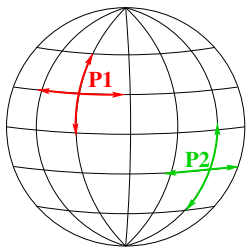

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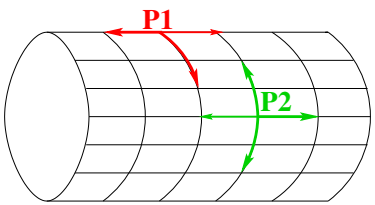

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- Cone $\Rightarrow$ idem Cylinder but with a variable radius

Discrete Curvature

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We use the Euler formula

$$k_n = k_{max} \cos^2(\theta) + k_{min} \sin^2(\theta)$$

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The neighbors are studied to approximate k_{max}, k_{min} and θ.

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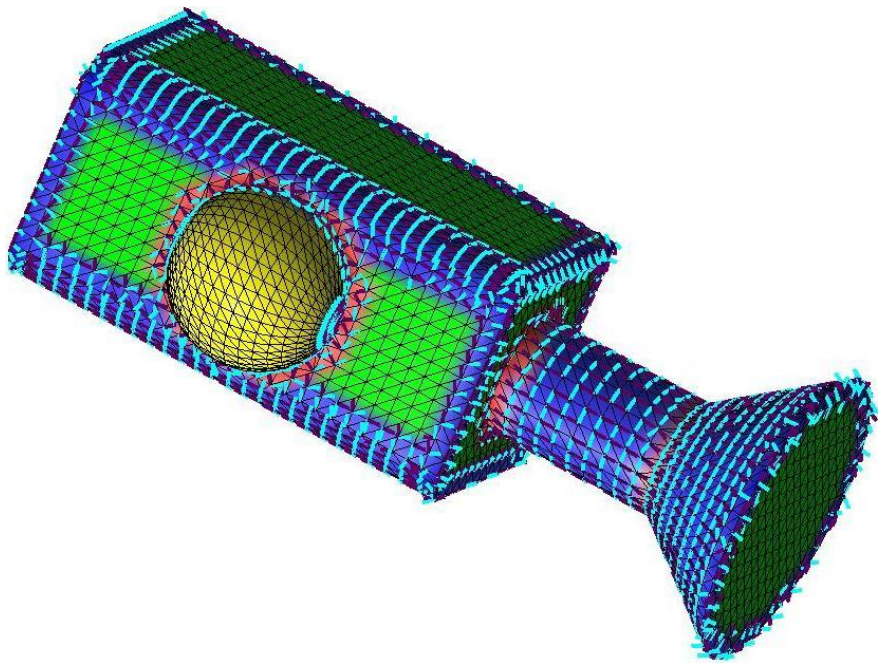
Concave Point
Convex Point
Saddle Point
Plane Point
Spheric Point



Planes Extraction

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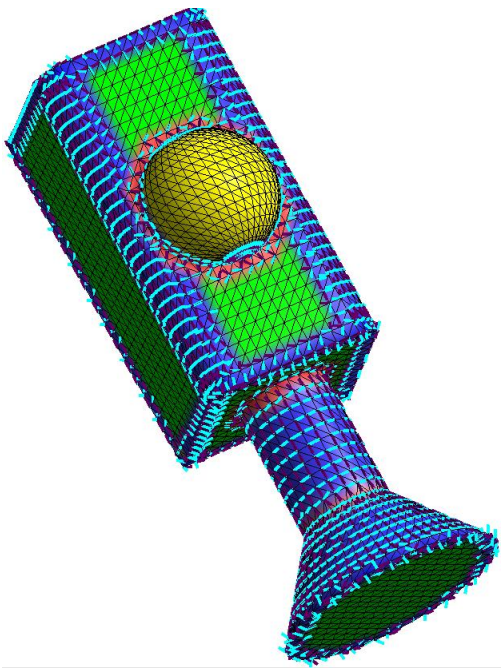

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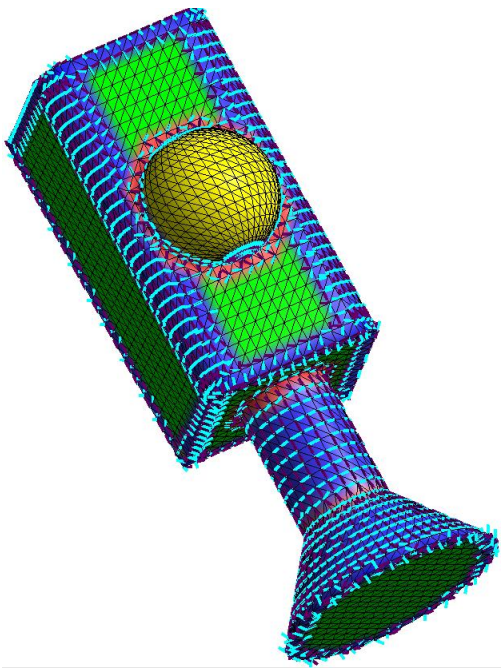

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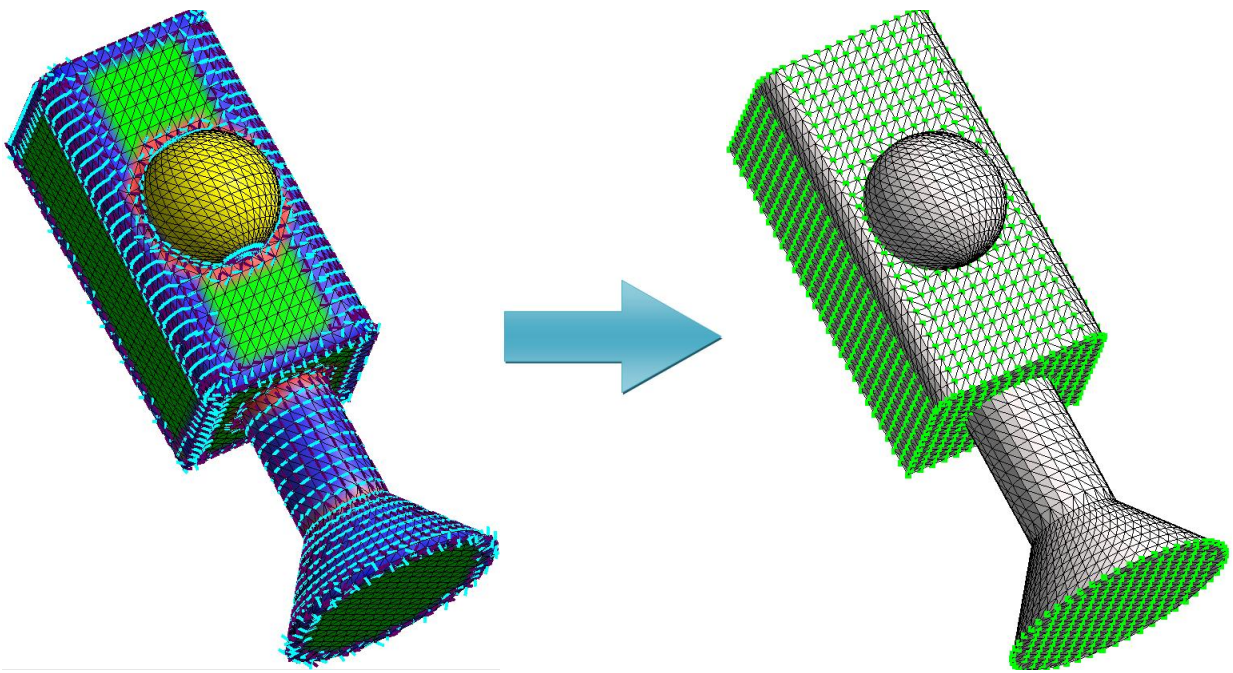

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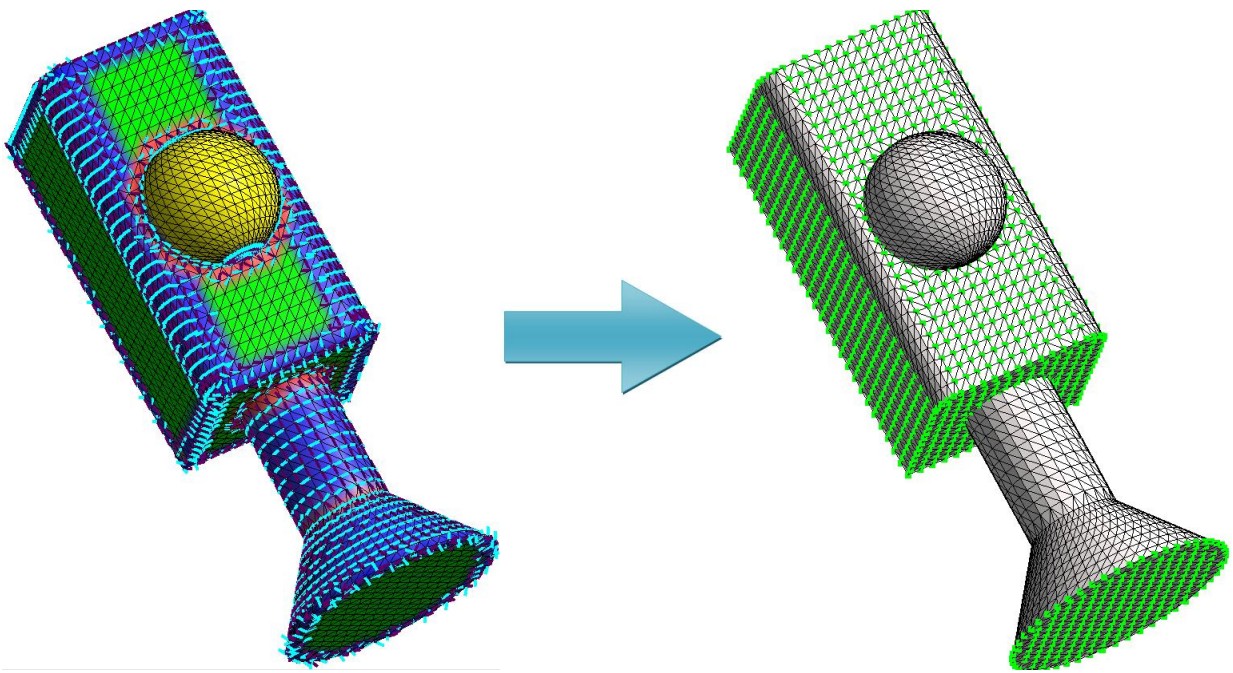

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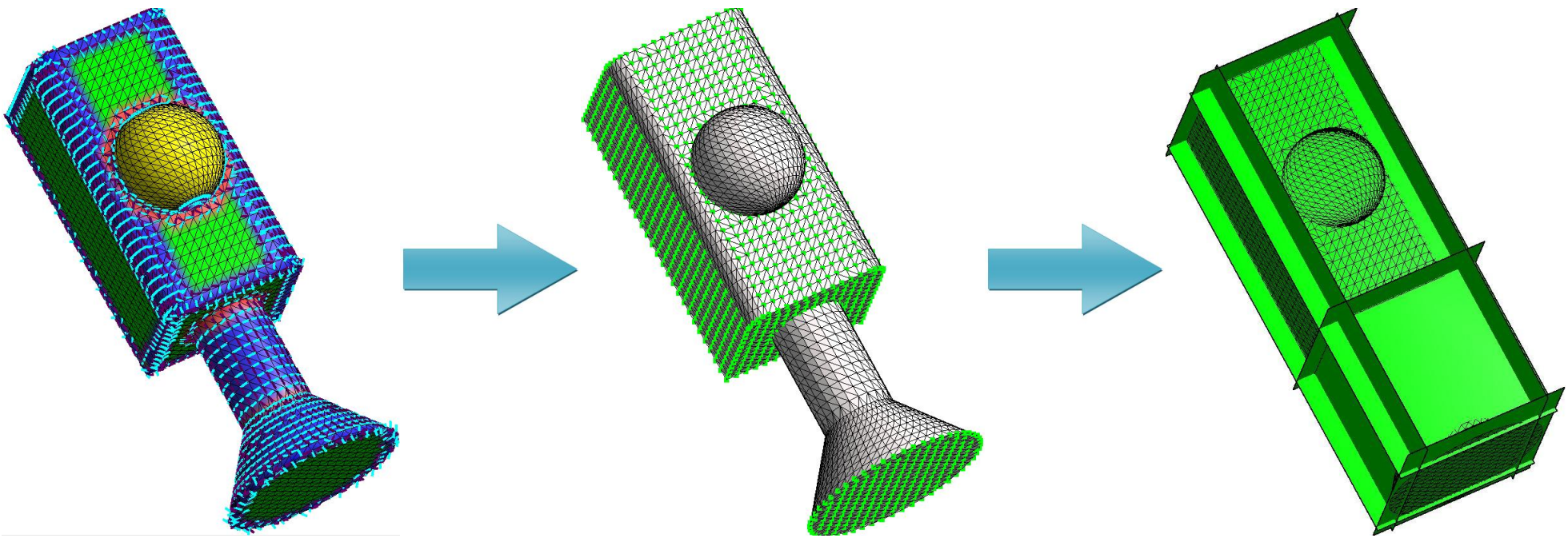

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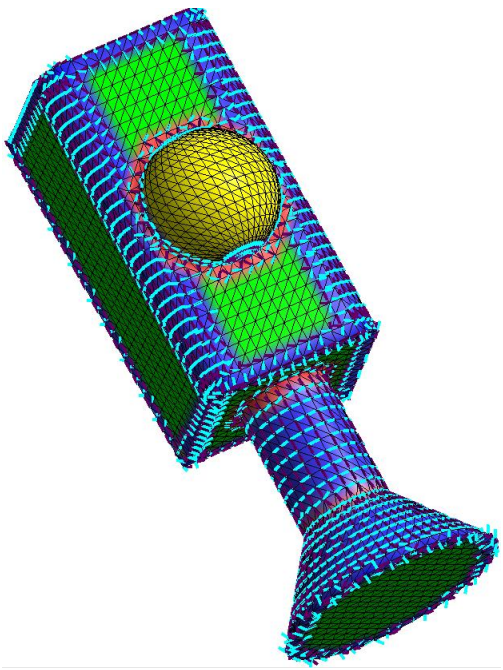

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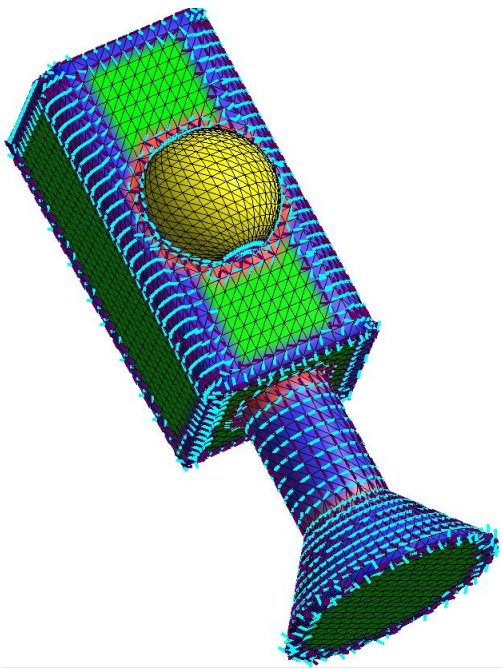

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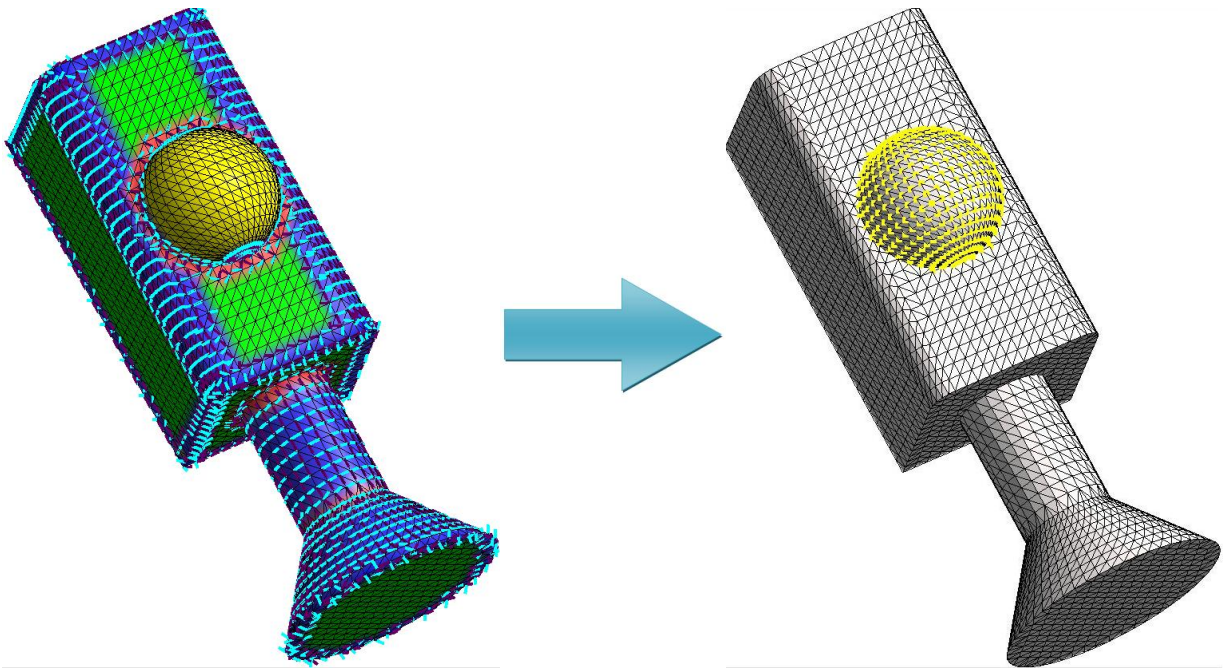

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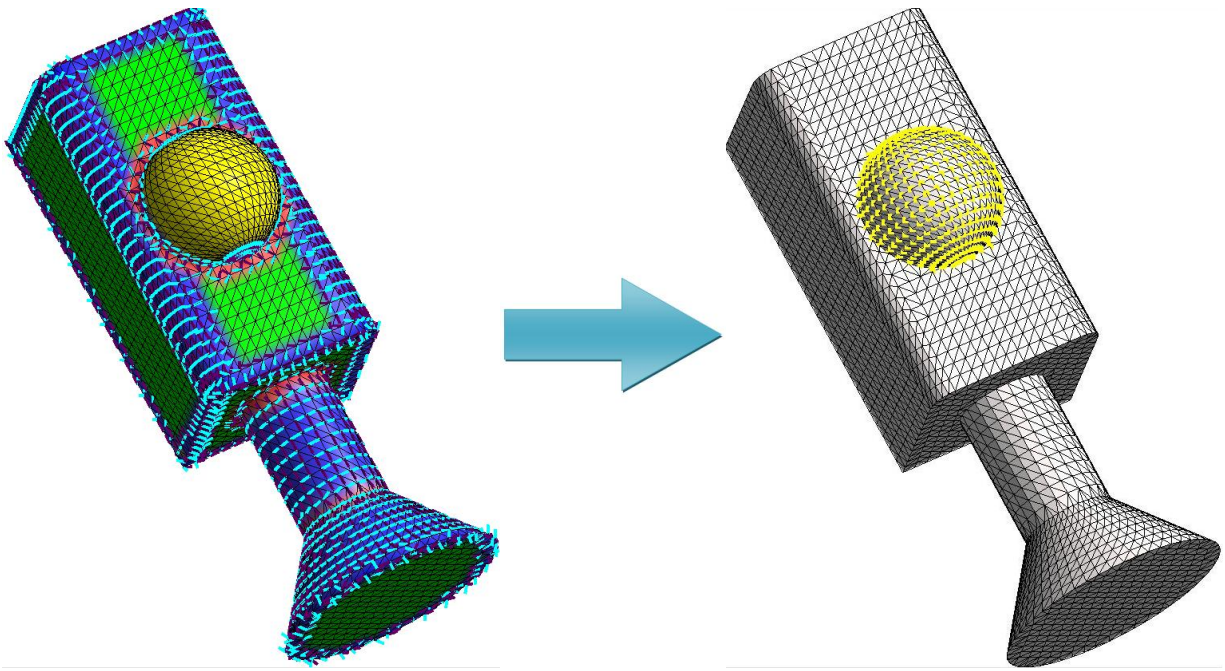
- Group all adjacent points with $k_{max} = k_{min} \approx K$
- The radius and the center are approximated by a least square method

$\Rightarrow$ The average of the curvature inverse is used to validate it



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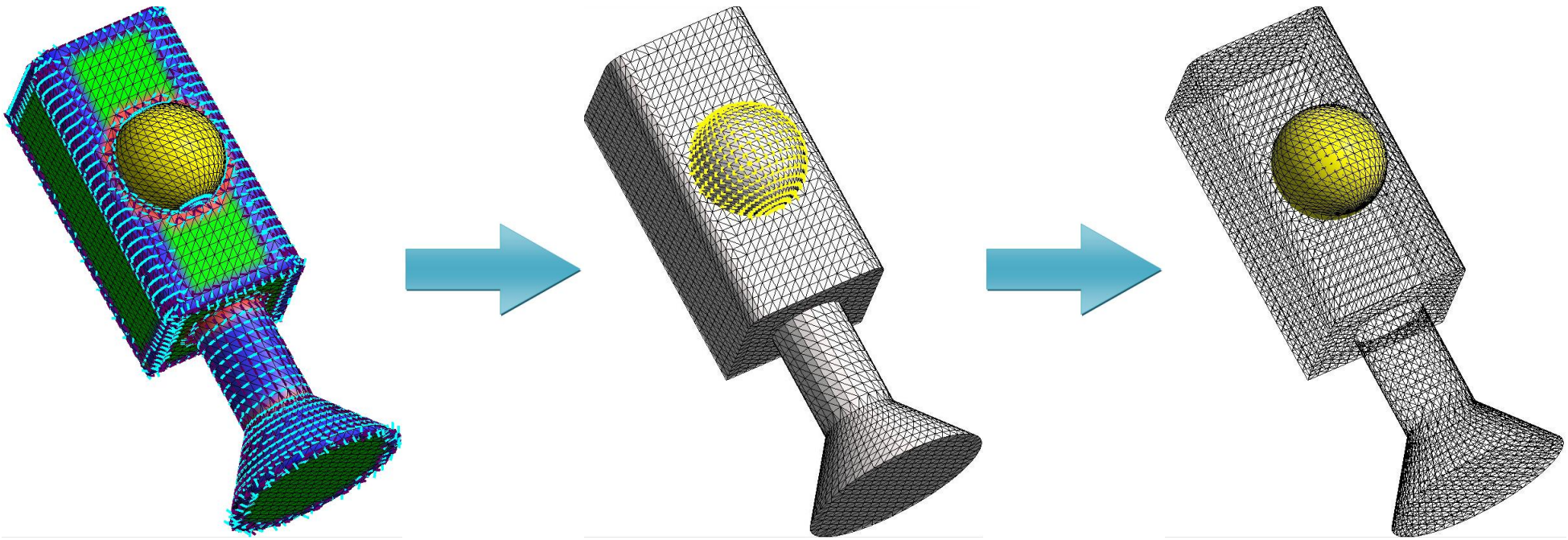
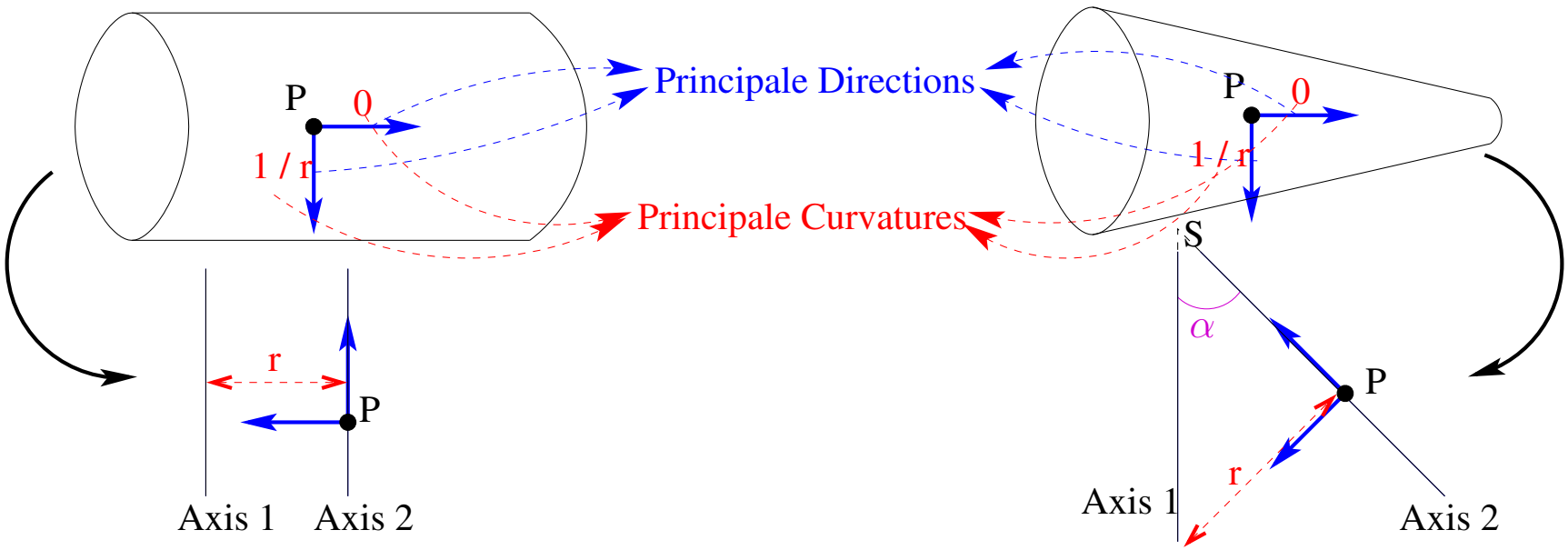


Cones/Cylinders Extraction

Features of Cones and Cylinders :



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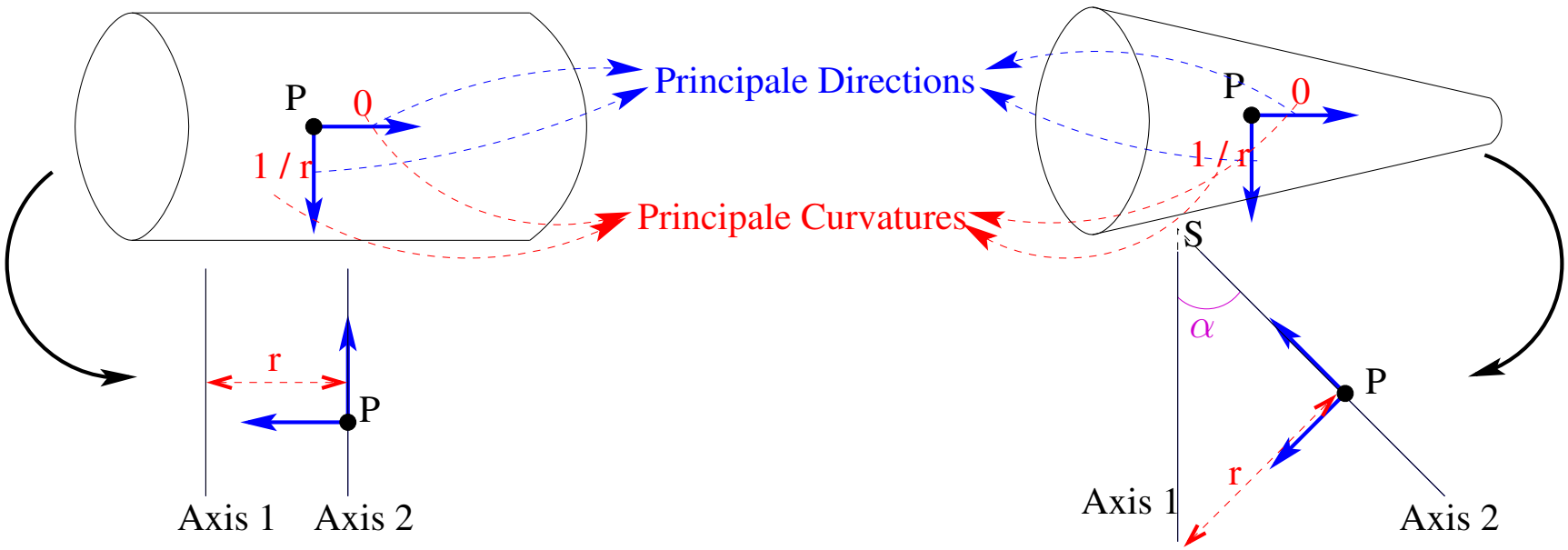
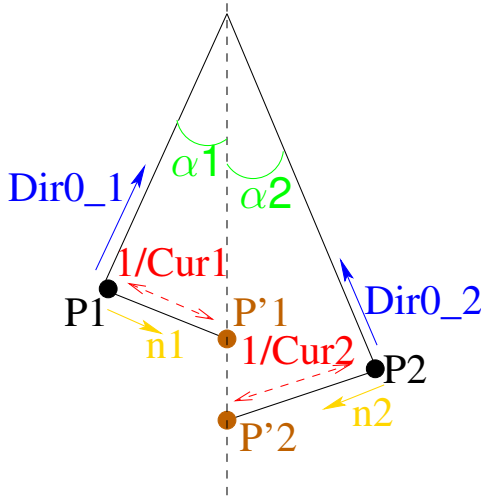


Criterion of belonging to a same cone :

If P_1 et $P_2 \in$ same cone

$\Rightarrow \alpha_1 = \alpha_2$



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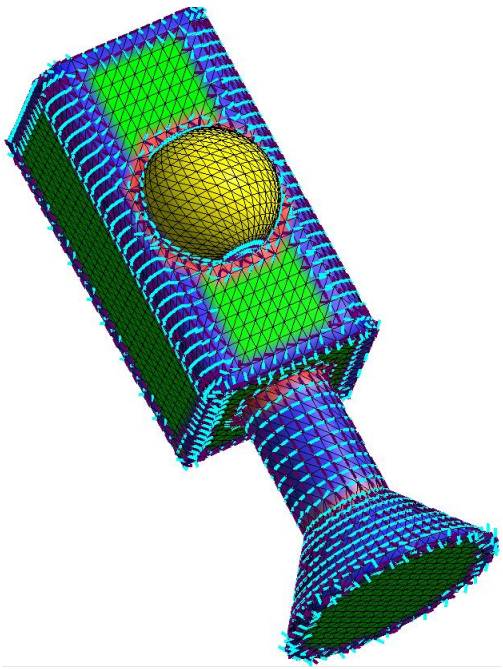

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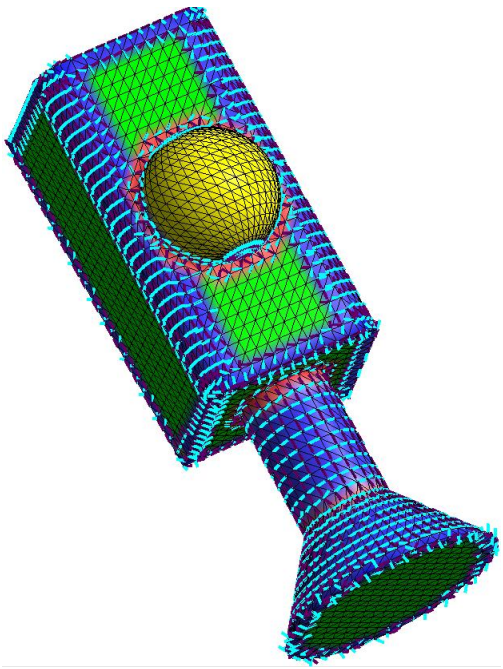

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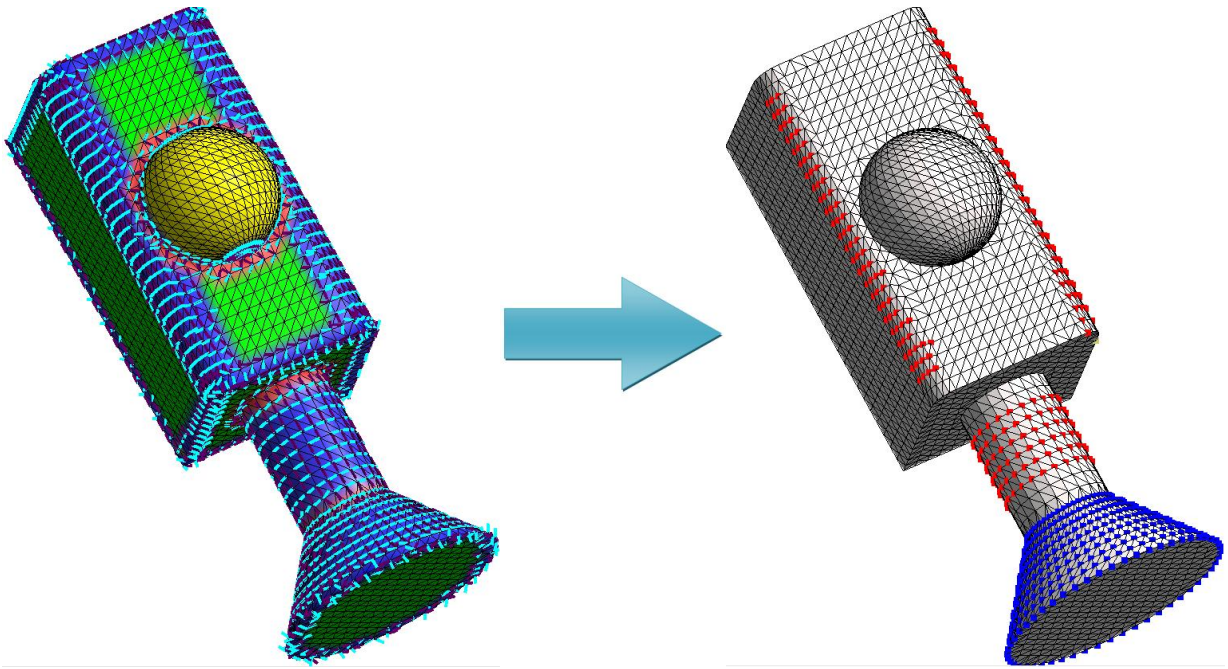

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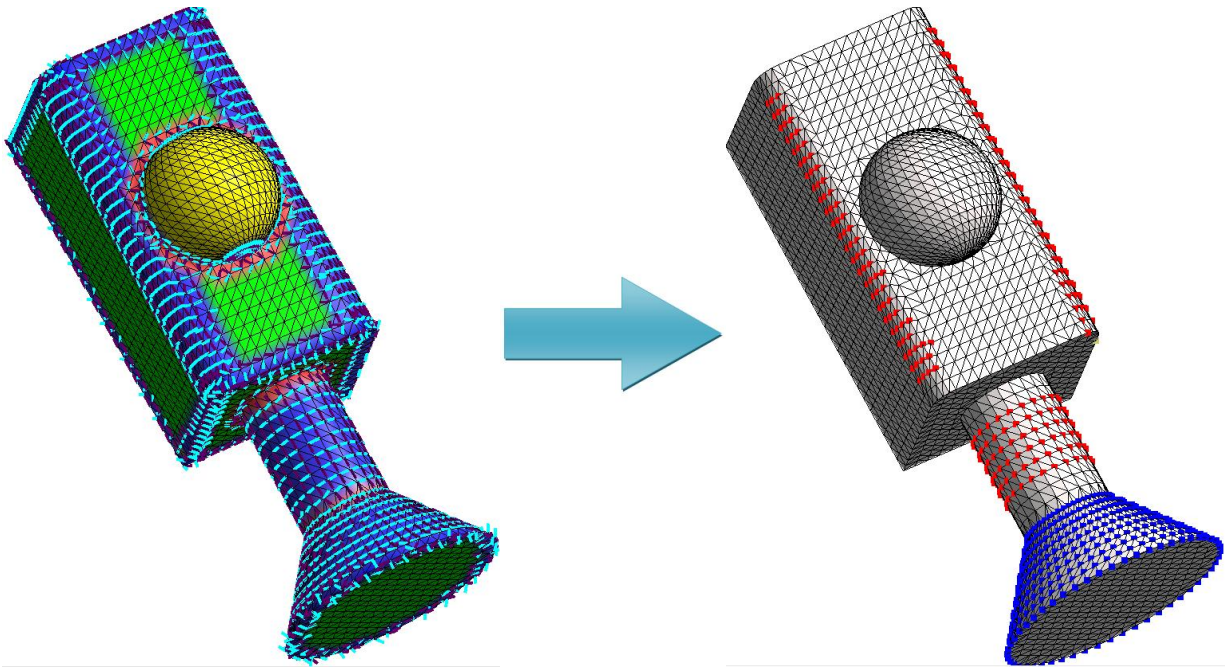
- For each point : $pointAxisTheo = point + normal * radius$
  $\Rightarrow$ Rotation Axis $\Rightarrow \alpha$ angle between Axis and $Dir_{=0}$
  - $\alpha = \pi \Rightarrow$ Cylinder : Average curvature $\Rightarrow$ Radius
  - $\alpha \neq \pi \Rightarrow$ Cone : Intersection between each plane created by the two principal directions of one point $\Rightarrow$ Vertex



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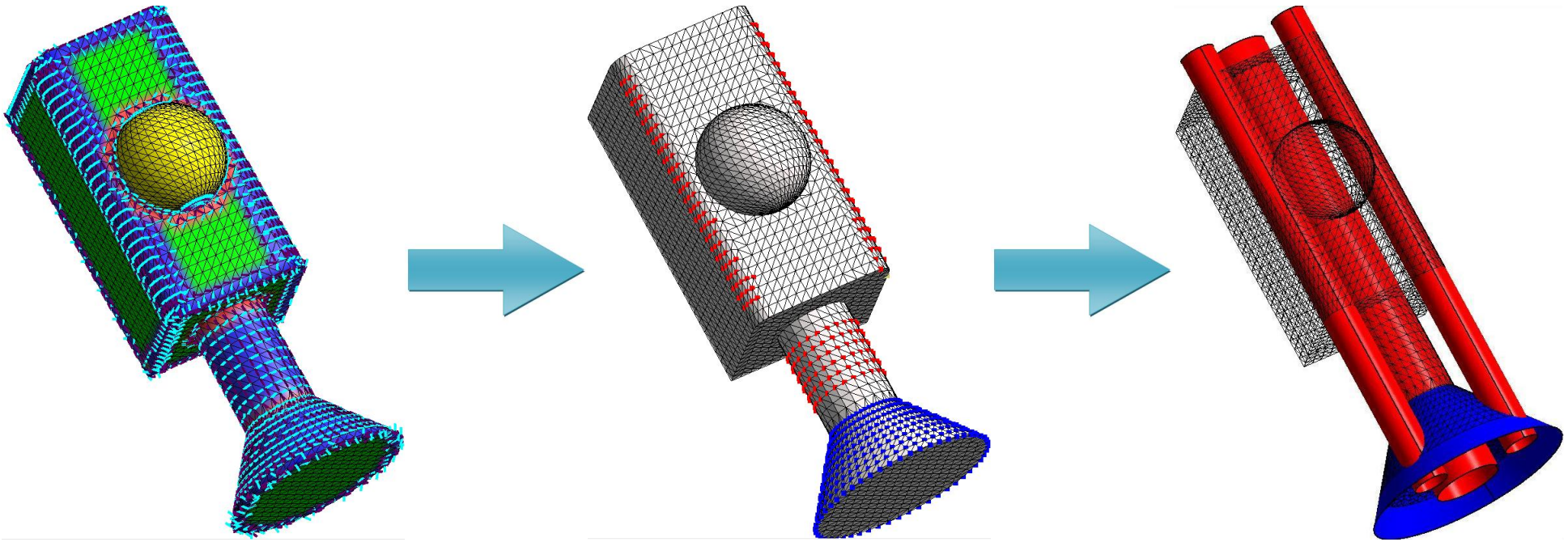
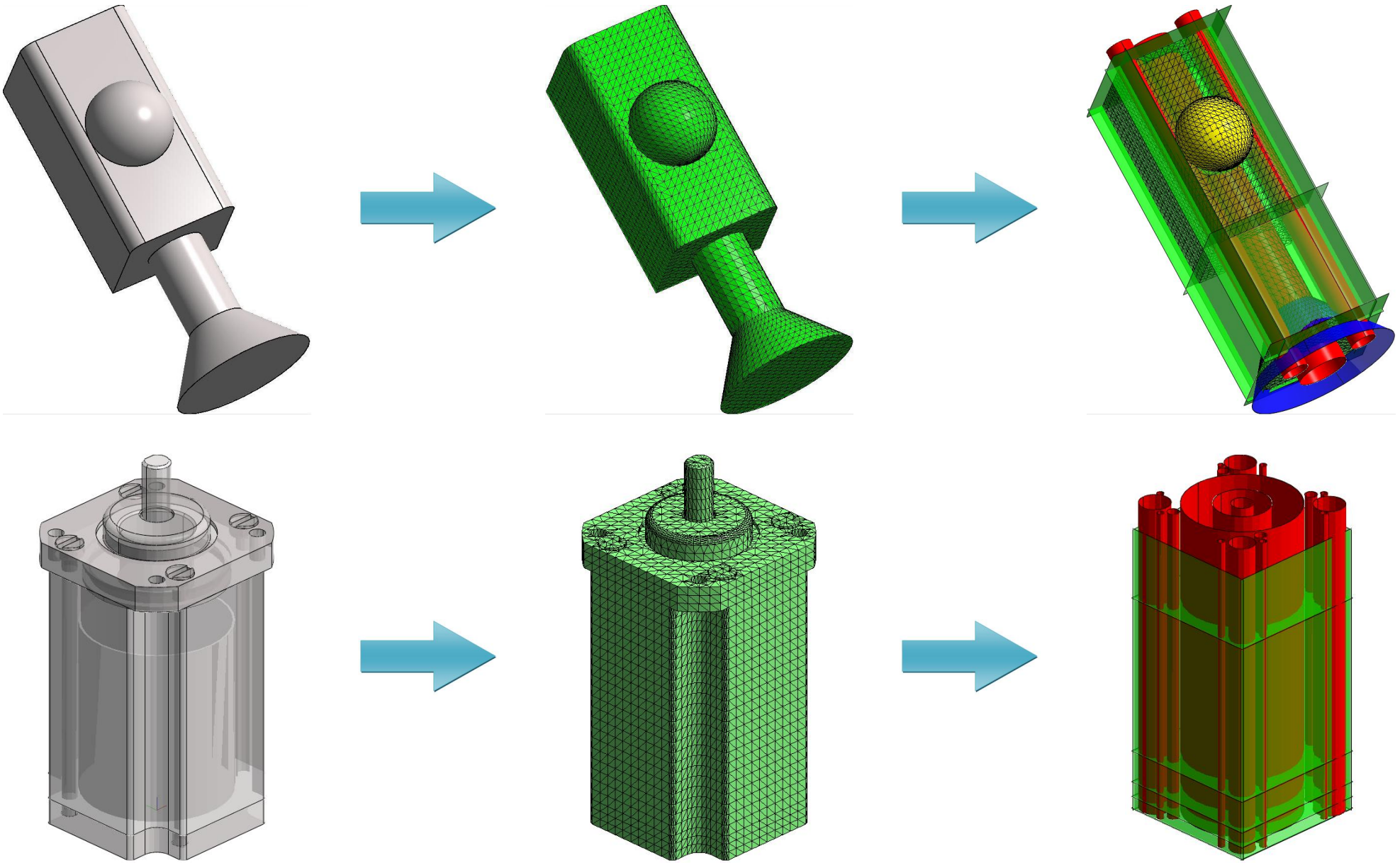


Results



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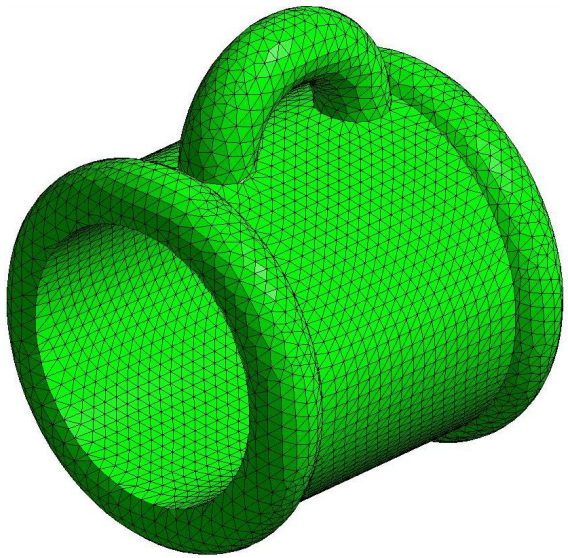
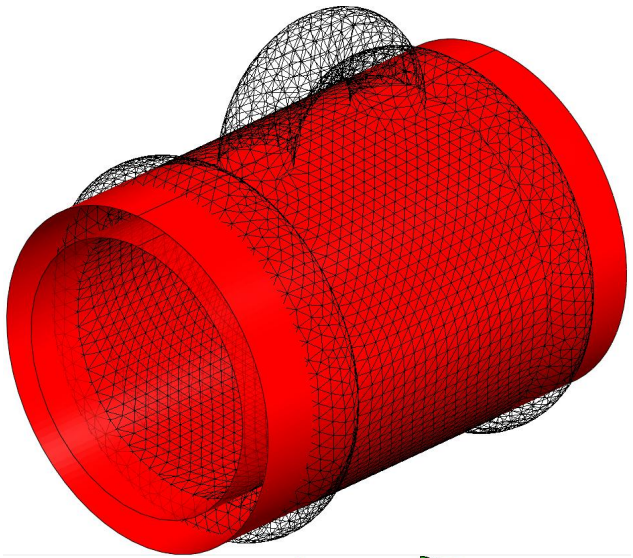
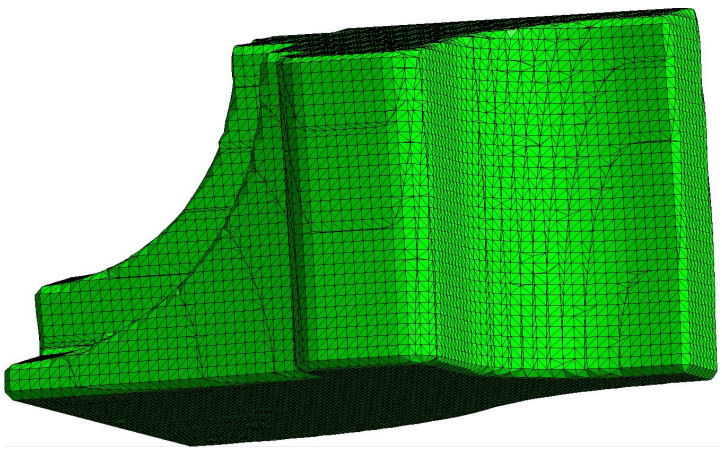
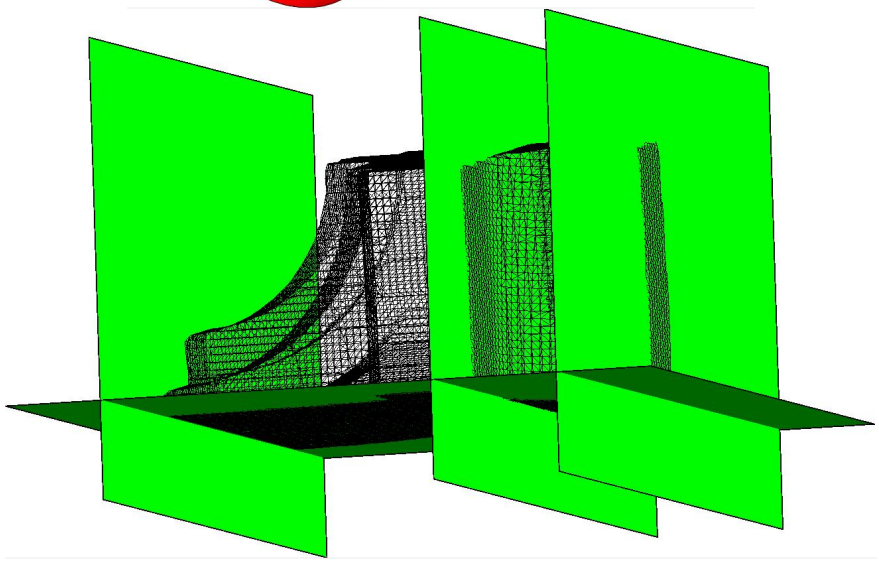




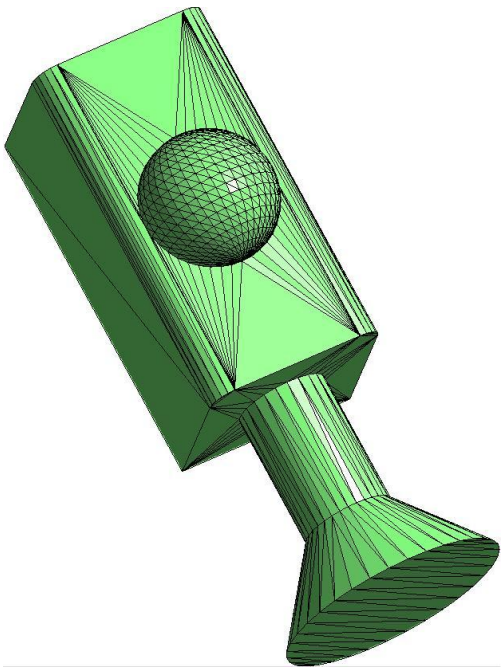




http ://shapes.aimatshape.net

Sparse Mesh

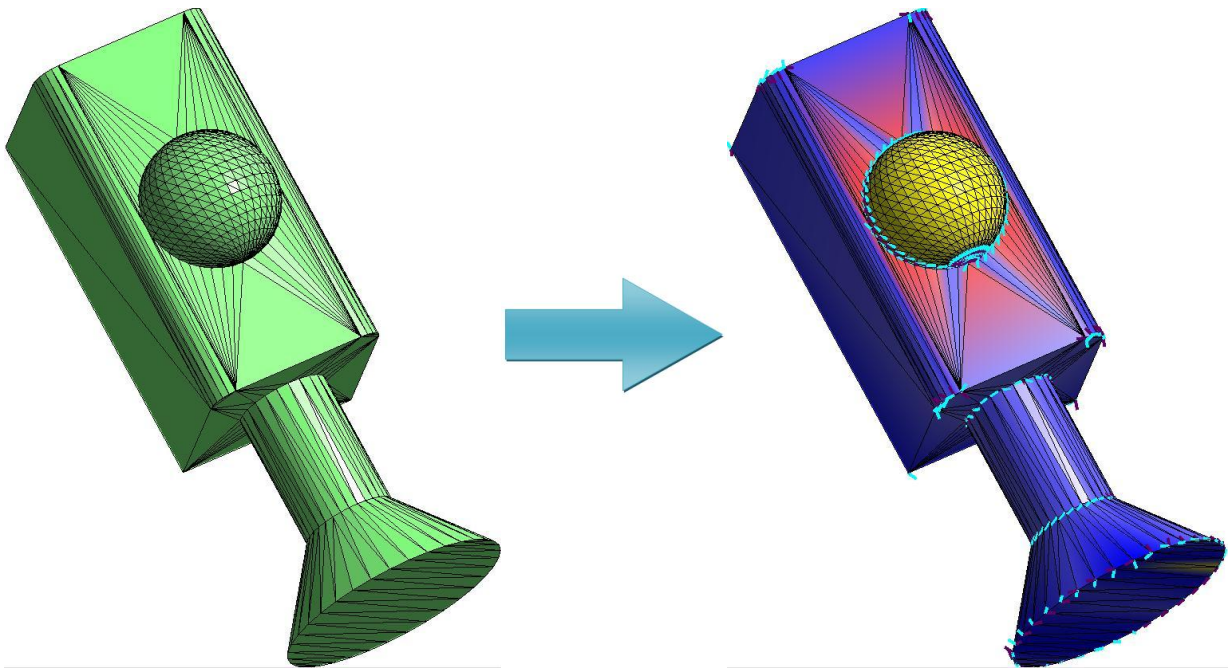
The mesh can not have many point



Sparse Mesh

The mesh can not have many point

$\Rightarrow$ The curvature computation is not correct

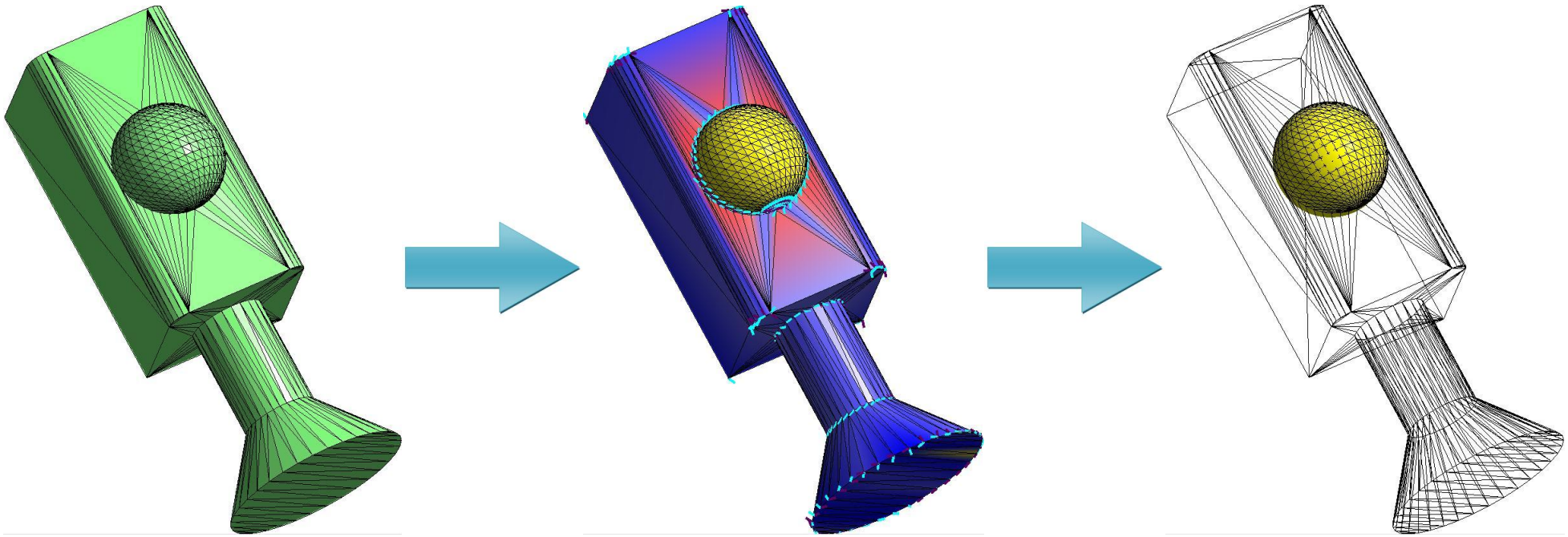


Sparse Mesh

The mesh can not have many point

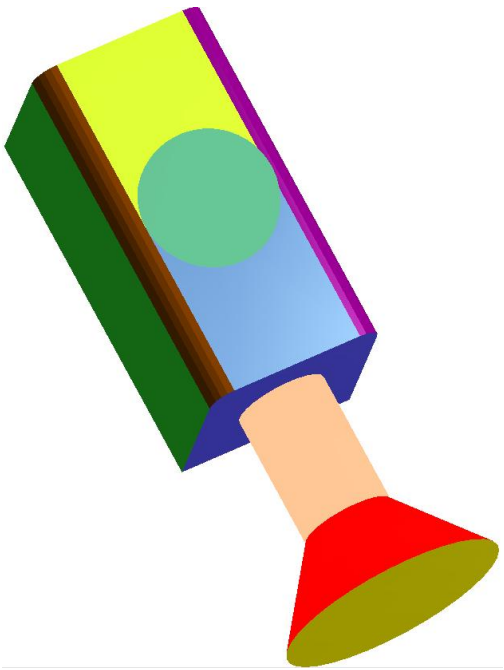
$\Rightarrow$ The curvature computation is not correct

$\Rightarrow$ The primitive extraction is disturbed



Sparse Mesh ⇒ Segmentation

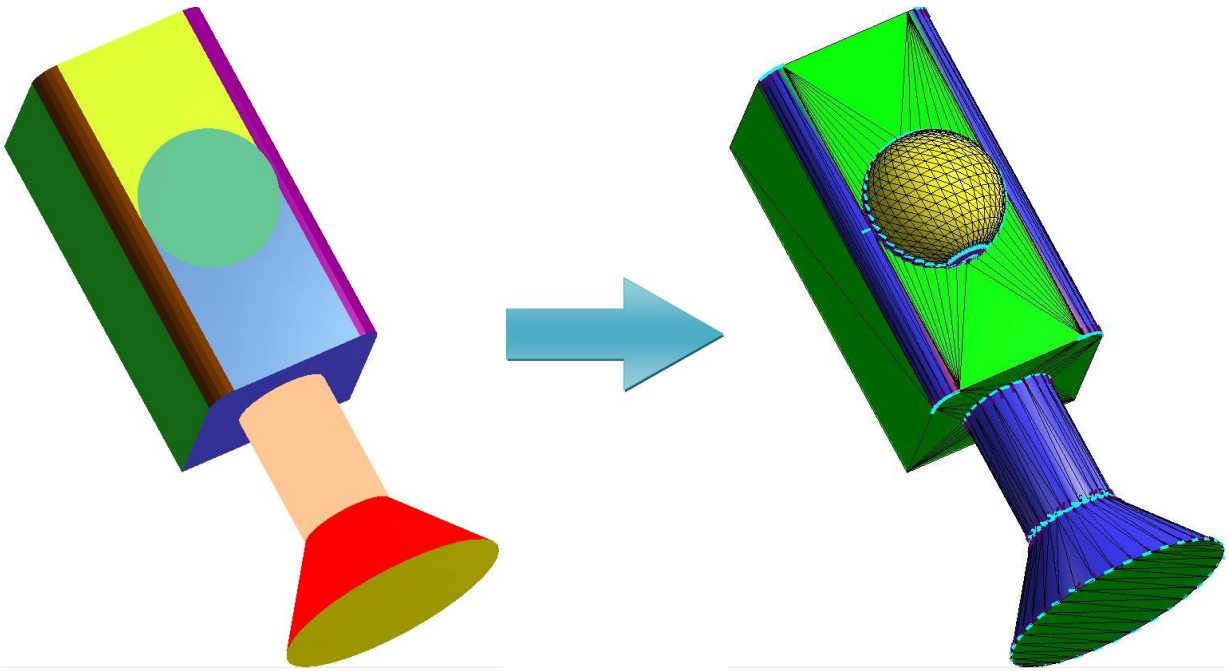
A solution can be to segment the mesh (by the dihedral angle for example)



Sparse Mesh ⇒ Segmentation

A solution can be to segment the mesh (by the dihedral angle for example)

⇒ The curvature computation is better

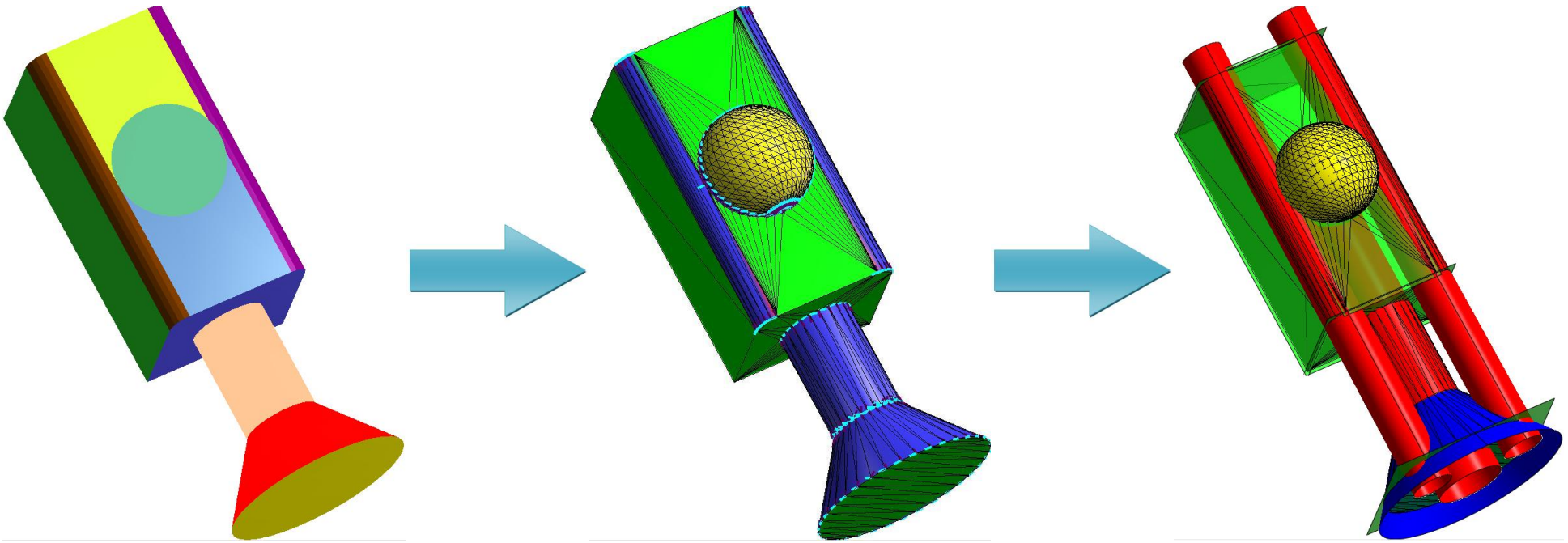


Sparse Mesh ⇒ Segmentation

A solution can be to segment the mesh (by the dihedral angle for example)

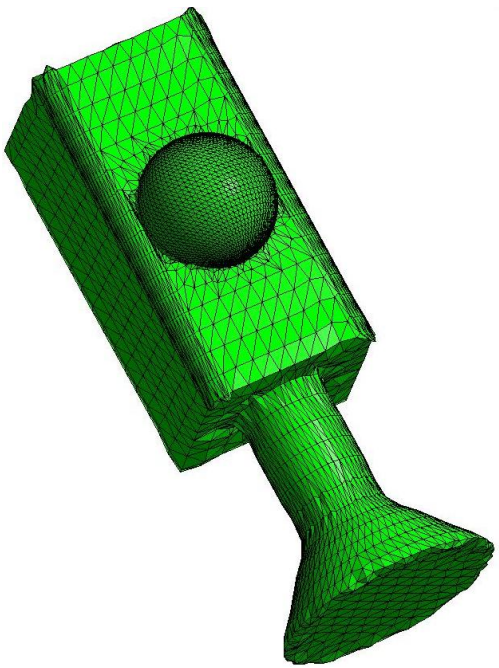
⇒ The curvature computation is better

⇒ The primitive extraction is improved



Noisy Mesh

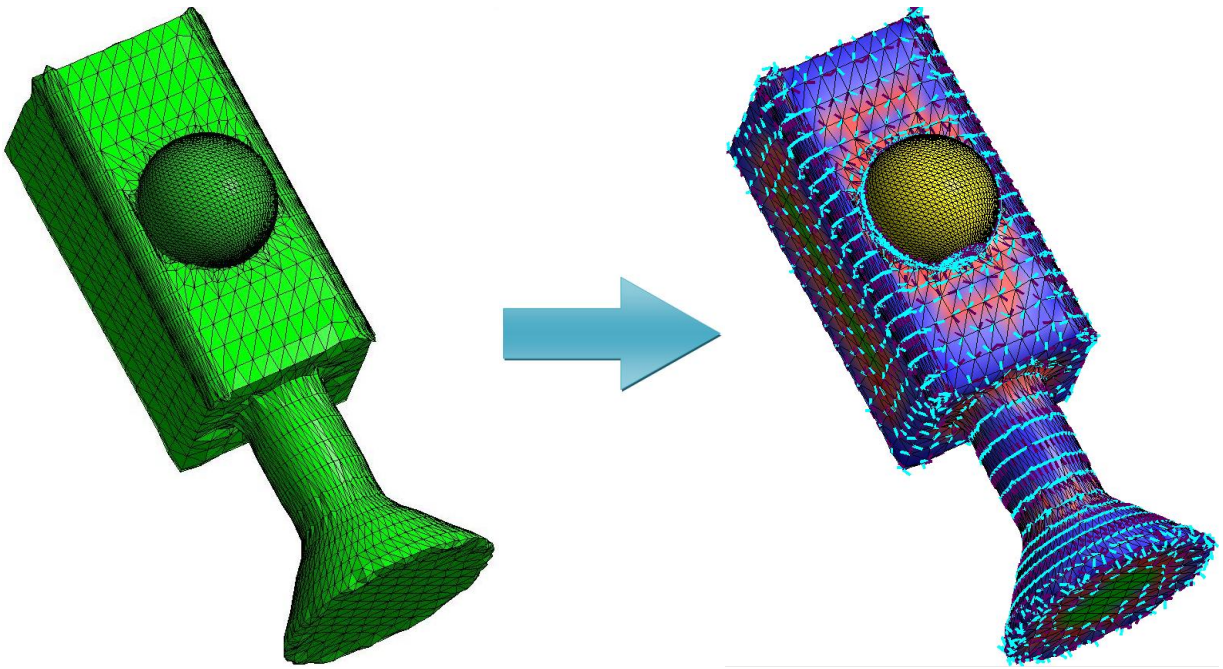
The mesh can not have many point



Noisy Mesh

The mesh can not have many point

$\Rightarrow$ The curvature computation is not correct

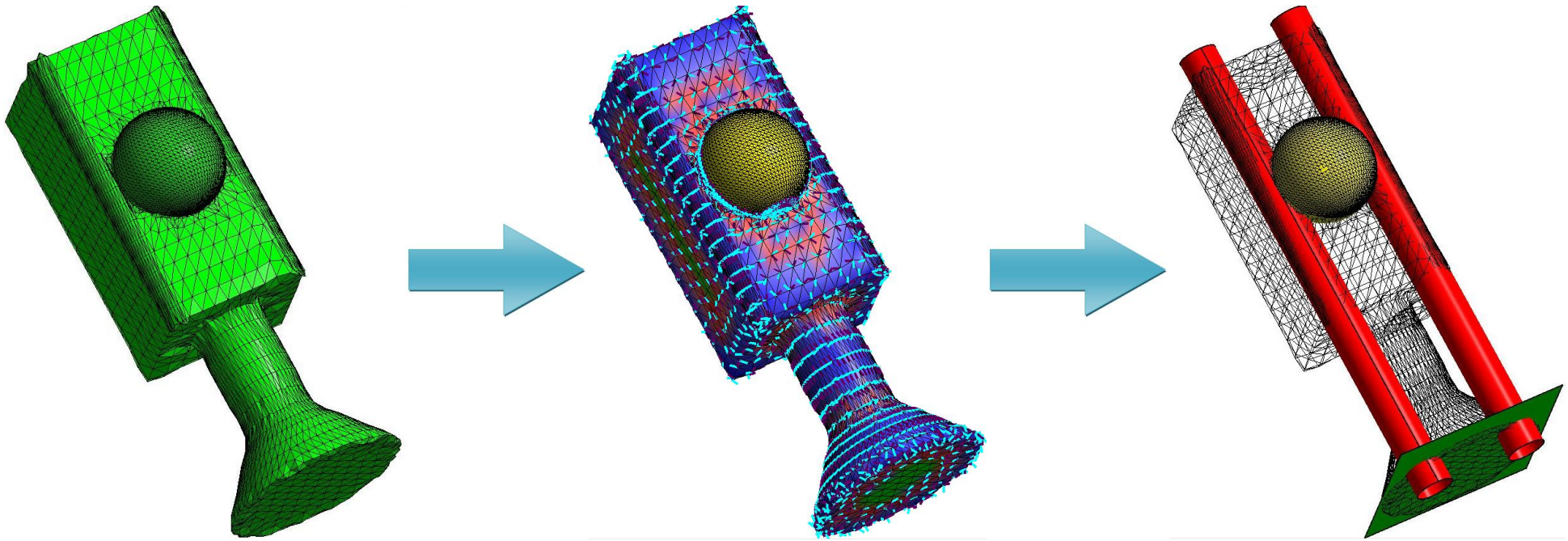


Noisy Mesh

The mesh can not have many point

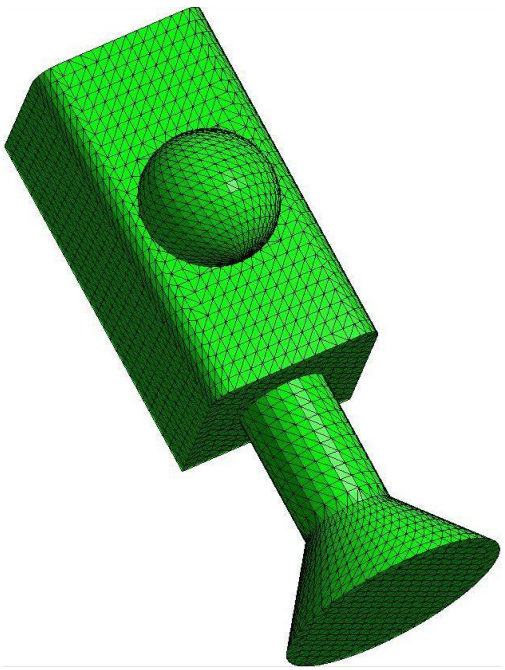
$\Rightarrow$ The curvature computation is not correct

$\Rightarrow$ The primitive extraction is disturbed



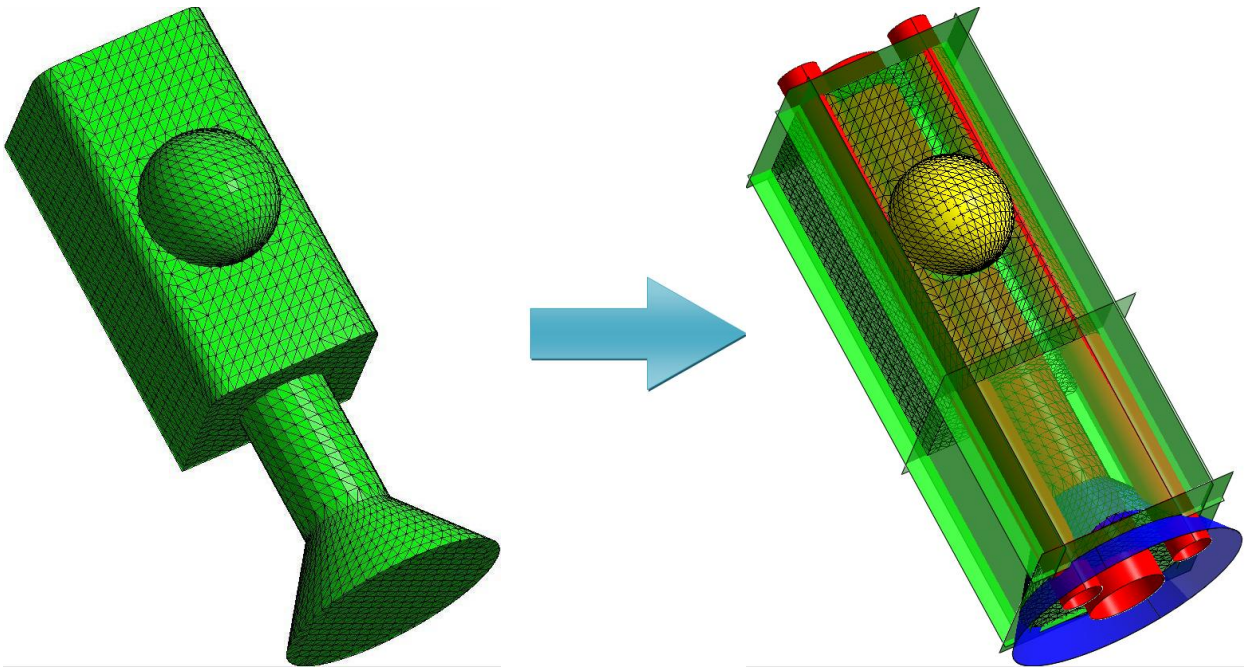
Conclusion and Future Work

Our method take a Mesh



Conclusion and Future Work

Our method take a Mesh $\Rightarrow$ extract primitives.

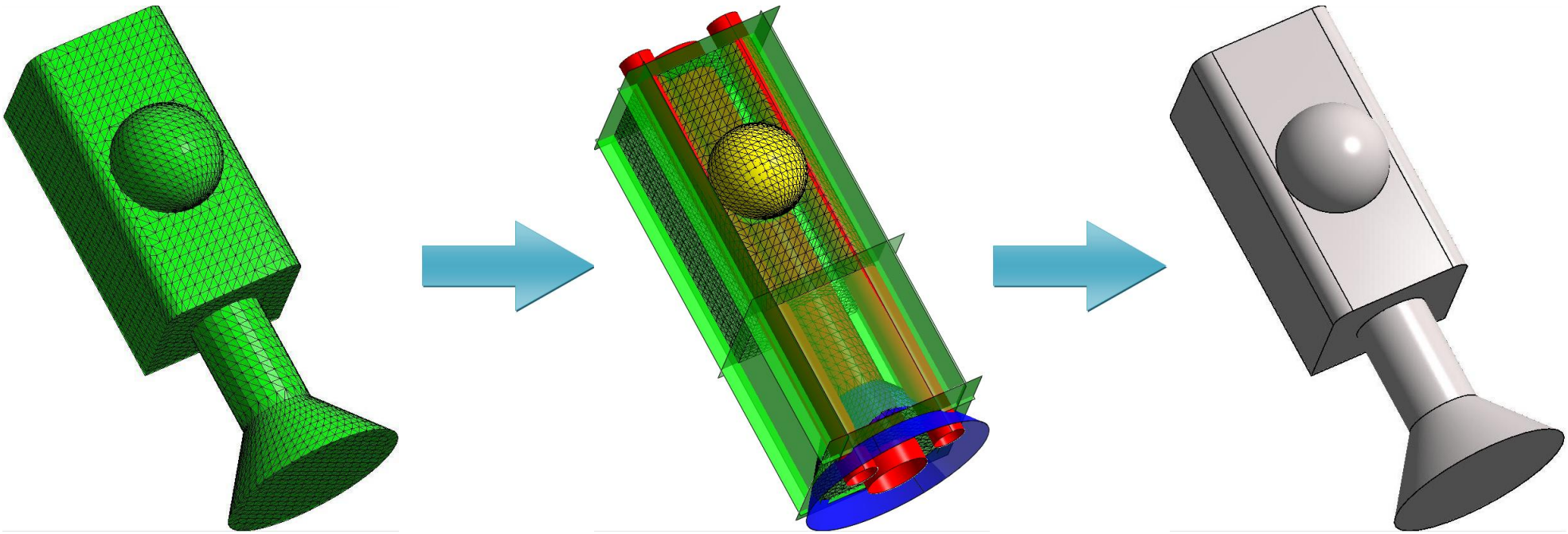


Conclusion and Future Work

Our method take a Mesh $\Rightarrow$ extract primitives.

Future Work

- Cut and Fuse Primitives to reconstruct the continue representation

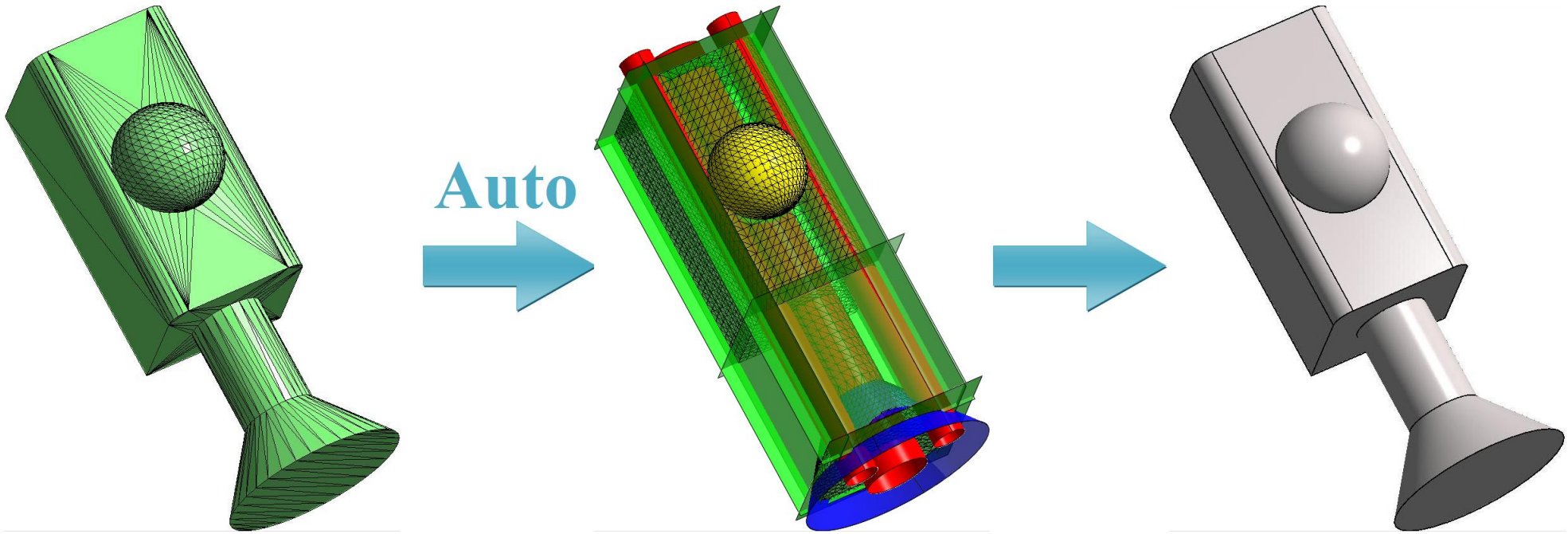


Conclusion and Future Work

Our method take a Mesh $\Rightarrow$ extract primitives.

Future Work

- Cut and Fuse Primitives to reconstruct the continue representation
- Add a Segmentation step to the method

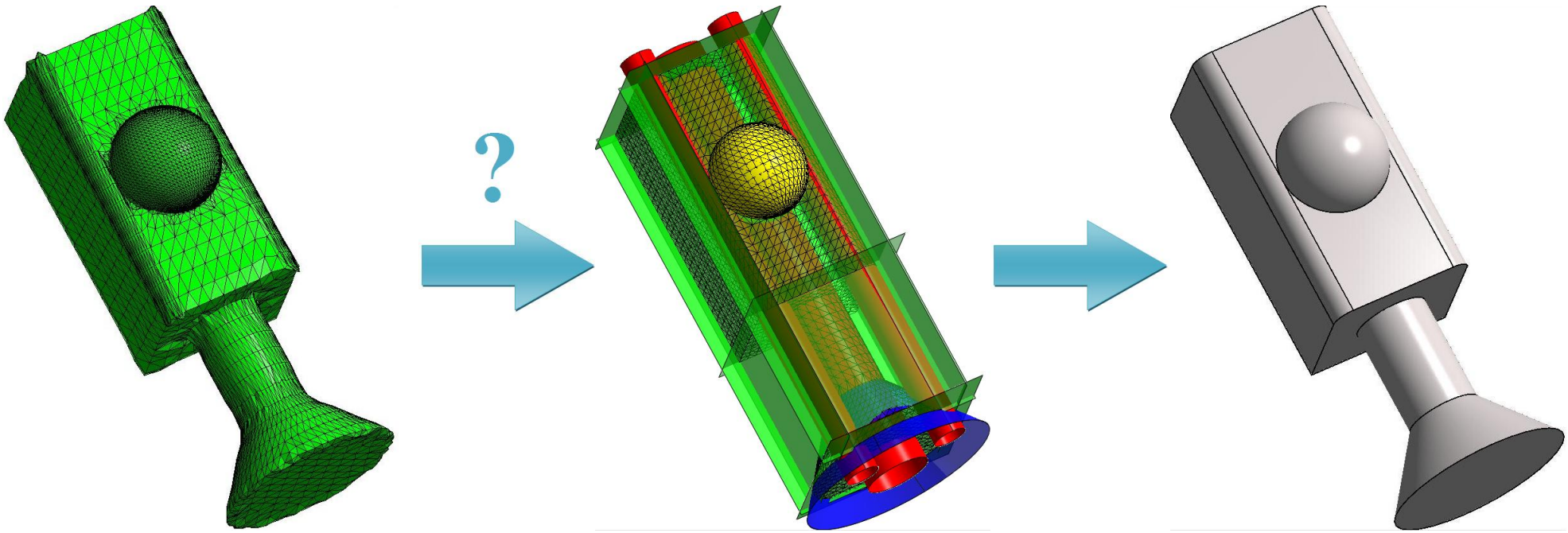


Conclusion and Future Work

Our method take a Mesh $\Rightarrow$ extract primitives.

Future Work

- Cut and Fuse Primitives to reconstruct the continue representation
- Add a Segmentation step to the method
- Deal with noisy mesh



Thanks for your attention

QUESTIONS ?

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C4W site : www.c4w.com

Roseline Bénière, G. Subsol, G. Gesquière, F. Le Breton and W. Puech,
Recovering Primitives in 3D CAD meshes, SPIE, *San Francisco*, 2011

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