# CAPS:

# Computational Aircraft Prototype Syntheses

Monthly Report – February 2018

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#### REPORT DOCUMENTATION PAGE

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The objective of this effort is to establish a computational geometry, meshing and analysis model generation tool that						
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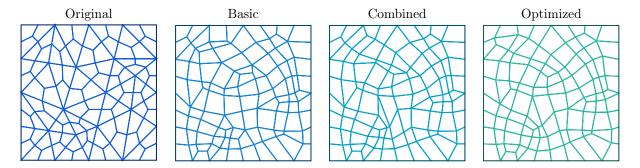


Figure 1: Illustration of the regularization process showing the initial mesh (left), the single element operation process (second image), further regularization by combining swap&split and the final mesh afer being optimized (right.

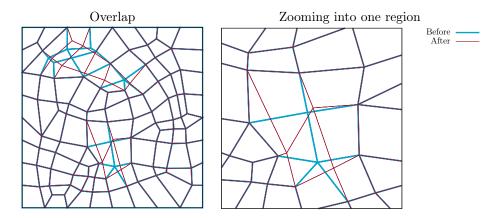


Figure 2: Swap&split operation: the left plot shows all the places where we could apply the technique and the right plot is a zoom of the lower swap and split step showing how we have gone from three irregular vertices (2 valence 5, 1 valence 3) to 1 irregular vertex (valence 5).

## 1 Combined Operations

## 2 Curvature Driven Element Sizing

Let  $K_1$  and  $K_2$  denote the principal curvatures and  $\vec{k}_1, \vec{k}_2$  the principal directions. We will cast the optimization problem based on the surface curvature in the following way: reallocate the vertices so that they are aligned with the principal directions and the edge size reflects the underlying curvature.

- 1. Element Orientation. During the local (global) optimization process, we combine the equi-angle approach with the principal curvature directions; for irregular vertices (valence  $\neq$  4), since we cannot align with the curvature directions (two directions = four edges) we compute the error assuming that the optimal distribution will produce equal internal angles. On the other hand, for regular vertices, we proceed as follows. At each vertex:
  - Get principal directions.
  - Construct normal plane to the surface.
  - Project each of the linking vertices (edges) onto the normal plane.
  - Find the edge that is closest to any of the curvature directions (pivot).
  - Compute the four angles using the pivot as leading direction.

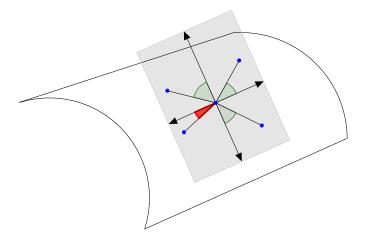


Figure 3:

Figure ?? illustrates this operation. At each vertex we obtain the principal directions and construct the normal plane.

2. Element Size. We use an approach suggested in []. From any vertex, we compute a metric based on the local curvature approximating the arc-length by the chord:

$$s = \frac{\ell}{1 - \epsilon} \tag{1}$$

$$s = \frac{\ell}{1 - \epsilon}$$

$$g(\epsilon) = \sqrt{40(1 - (\sqrt{1 - 1.2\epsilon})}$$

$$(2)$$

where s denotes the arc-length,  $\ell$  the chord and  $\epsilon$  is a user defined tolerance. This equation is obtained by linearization, using that  $s = c\theta$ , being c the radius of curvature and  $\theta$  the angle with respect the principal curvature.