CAPS:
Computational Aircraft Prototype Syntheses

Monthly Report – February 2018

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14. ABSTRACT

The objective of this effort is to establish a computational geometry, meshing and analysis model generation tool that can be used across AFRL/RQV. This common tool will enable collaboration between conceptual design, multidisciplinary optimization and high fidelity simulation efforts.

15. SUBJECT TERMS

multidisciplinary analysis; multi-fidelity geometry; aircraft design; software infrastructure

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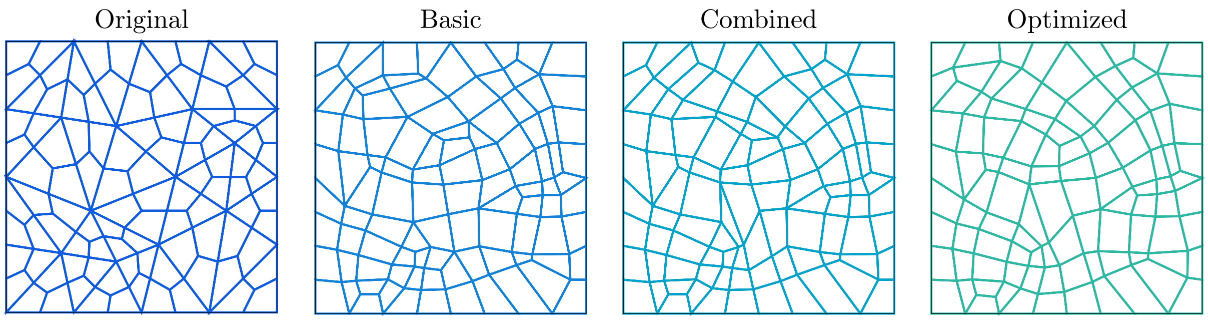

Figure 1: Illustration of the regularization process showing the initial mesh (left), the single element operation process (second image), further regularization by combining swap&split and the final mesh afer being optimized (right.

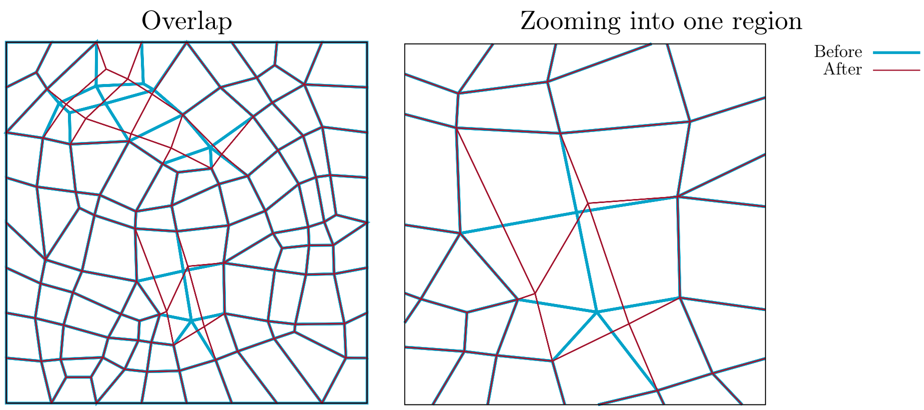

Figure 2: Swap&split operation: the left plot shows all the places where we could apply the technique and the right plot is a zoom of the lower swap and split step showing how we have gone from three irregular vertices (2 valence 5, 1 valence 3) to 1 irregular vertex (valence 5).

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.

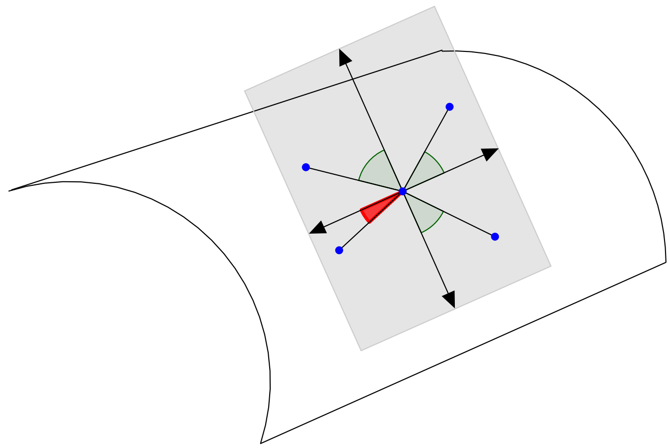

Figure 3:

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:

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

$$g(\epsilon) = \sqrt{40(1 - (\sqrt{1 - 1.2\epsilon})} \tag{2}$$

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