Natural control for multi-sided surfaces

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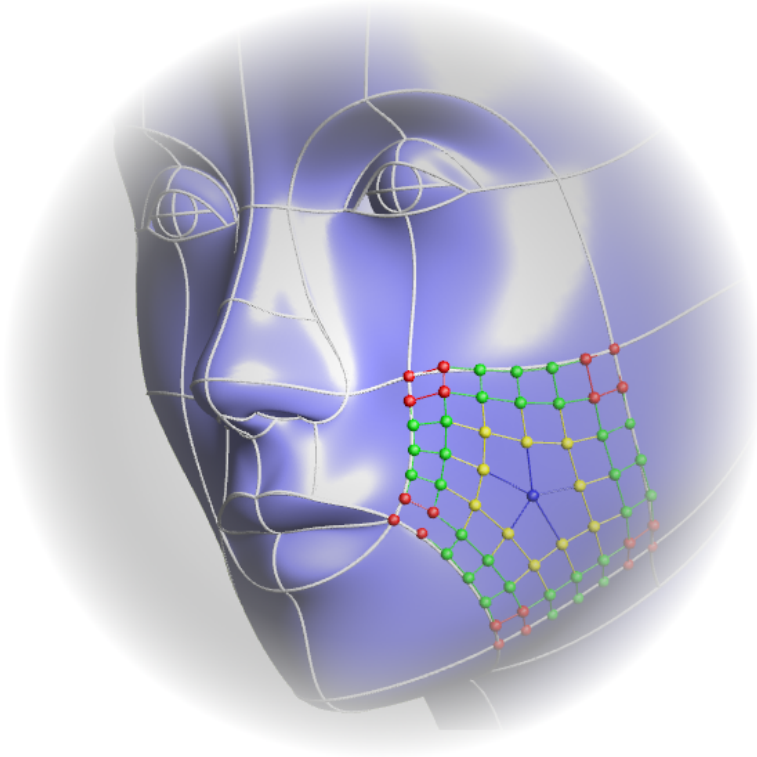
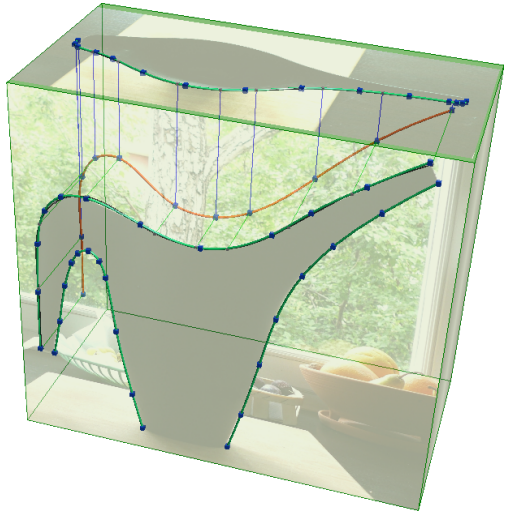
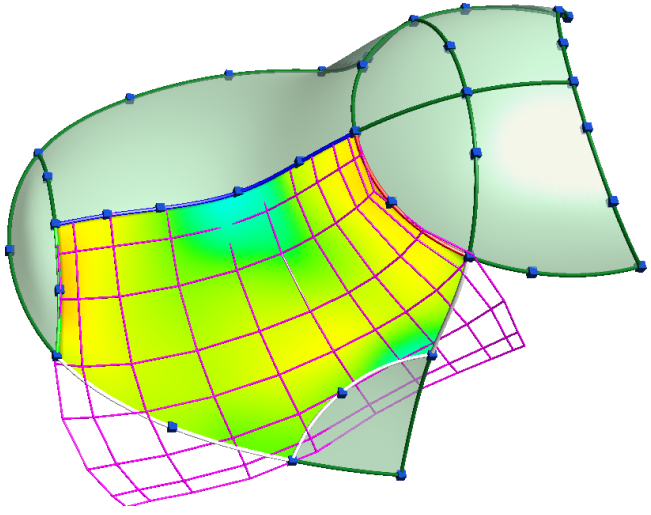
Outline

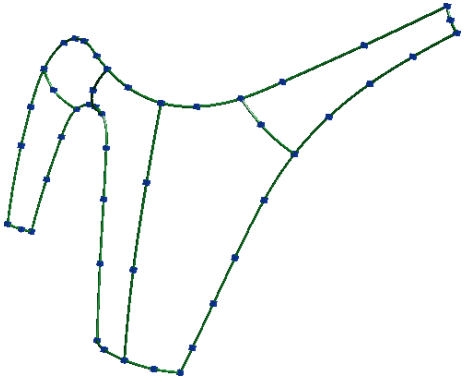
- Motivation
- Generalized Bézier patches
  - Curved domain
  - Generalized B-spline patches
- Ribbon generation
  - Cross-derivatives by parameters
- Interior control
  - Blending functions
- Tools for editing
  - Control vectors
  - Proportional editing
- Conclusion

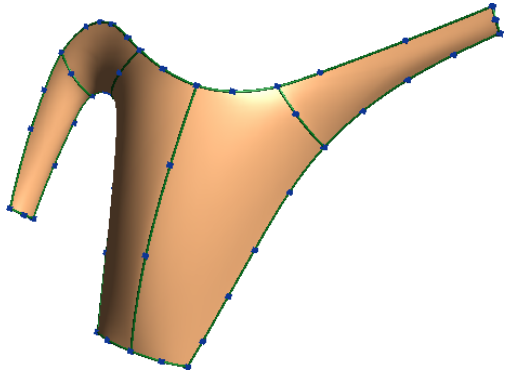


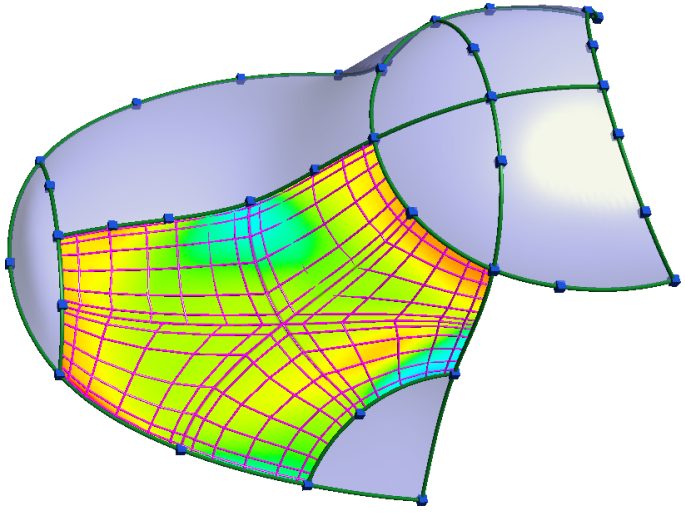
Multi-sided surfaces











Survey

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Genuine multi-sided parametric surface patches – A survey

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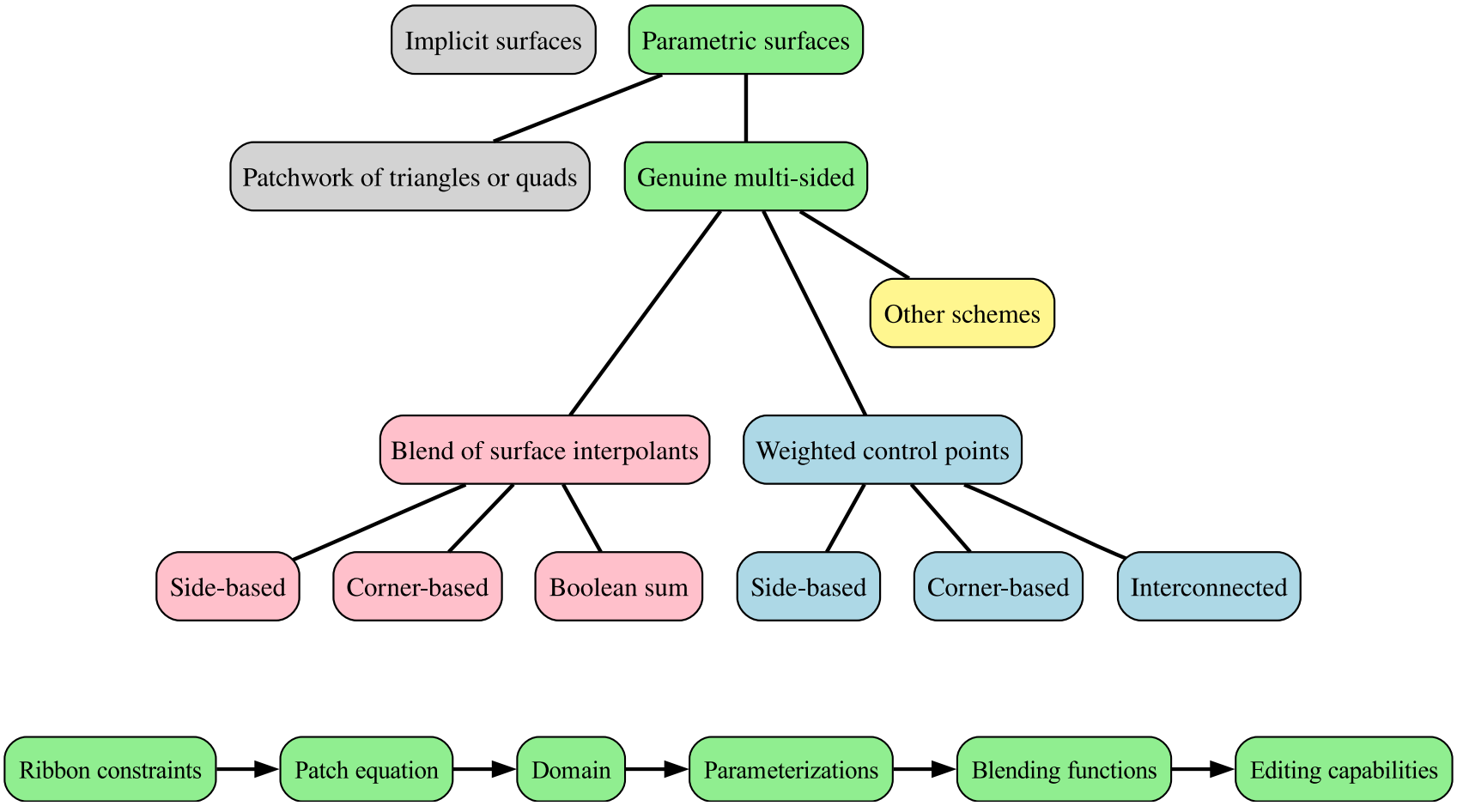
Ribbon-based surfaces
Transfinite interpolation
Control point patches
Surface modeling
General topology

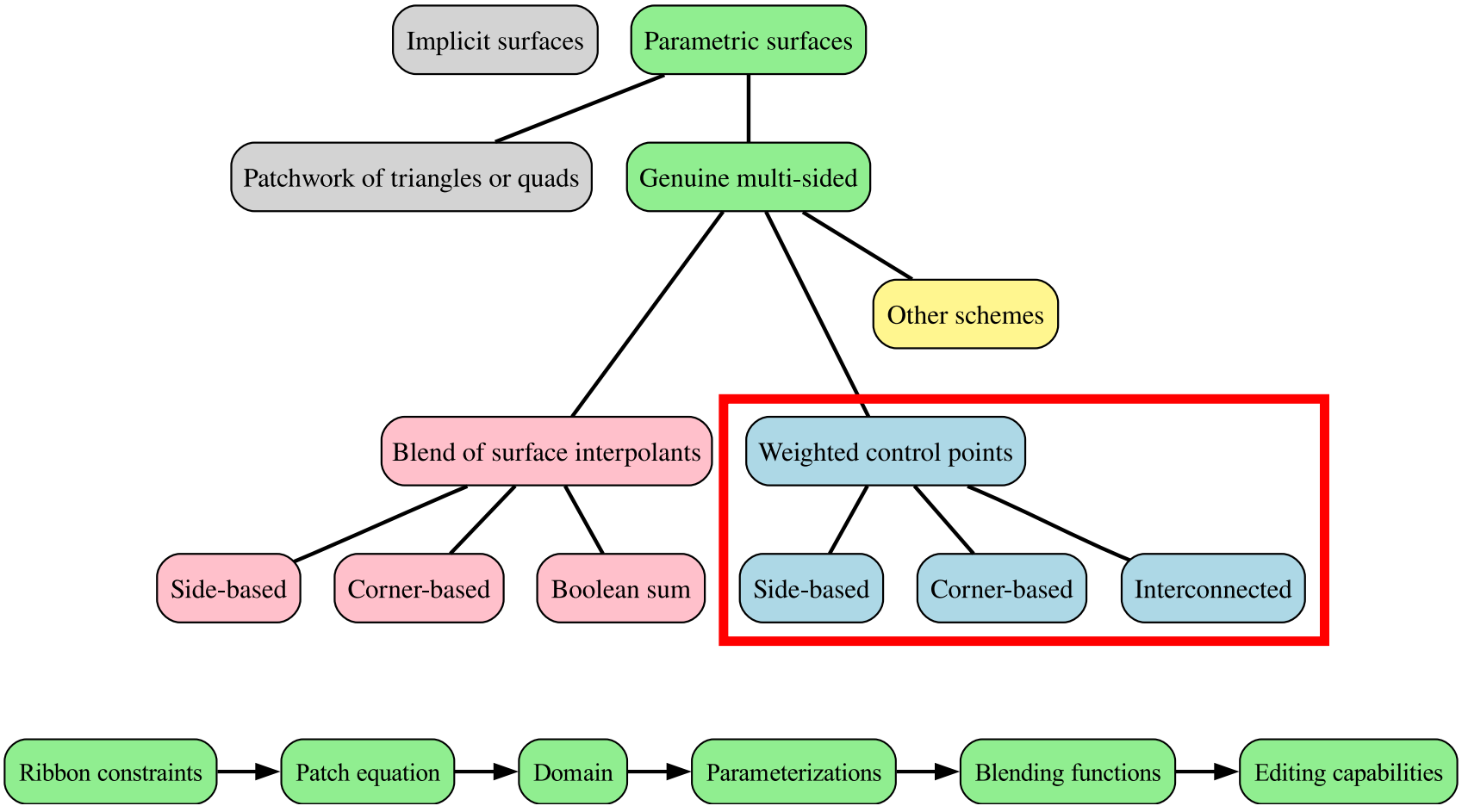
ABSTRACT

A state-of-the-art survey is presented on various formulations of multi-sided parametric surface patches, with a focus on methods that interpolate positional and cross-derivative information along boundaries.

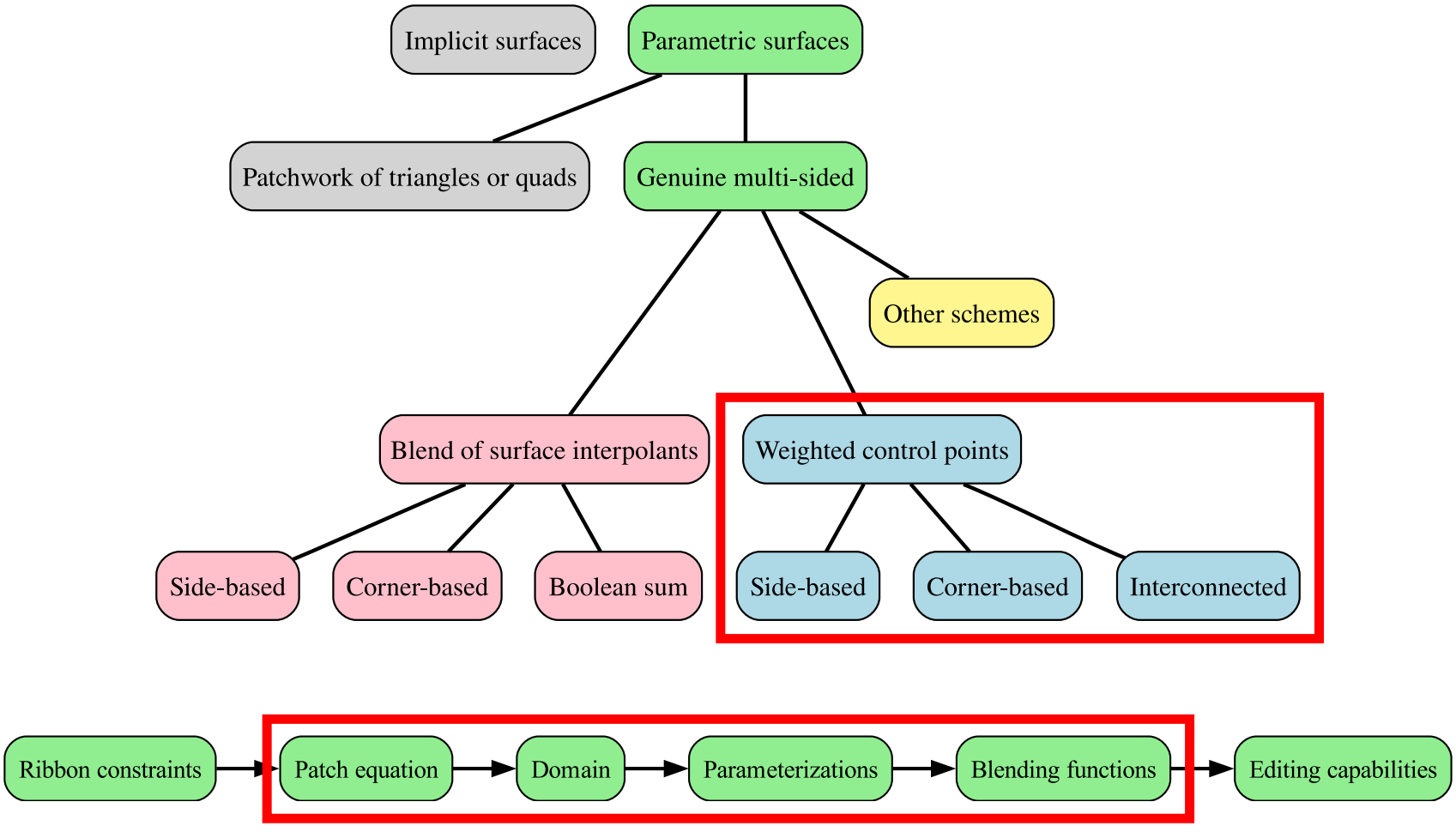
Classification and constituents



Classification and constituents

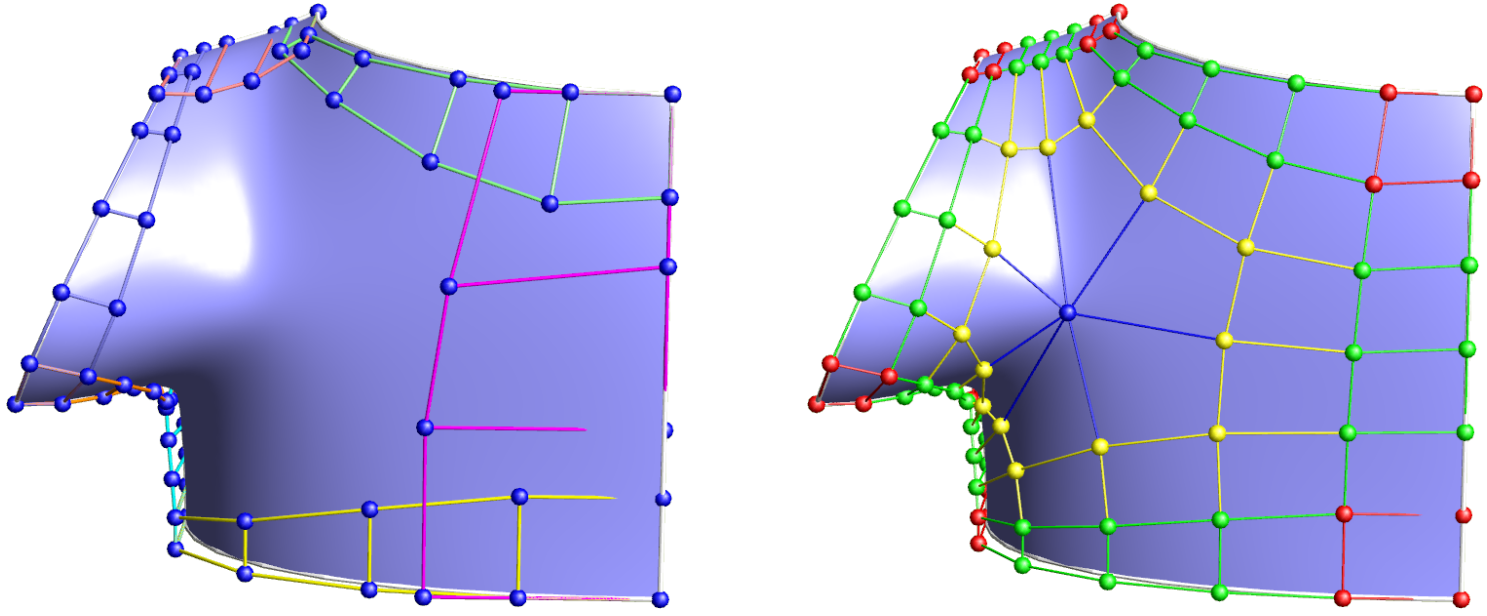


Classification and constituents



Outline

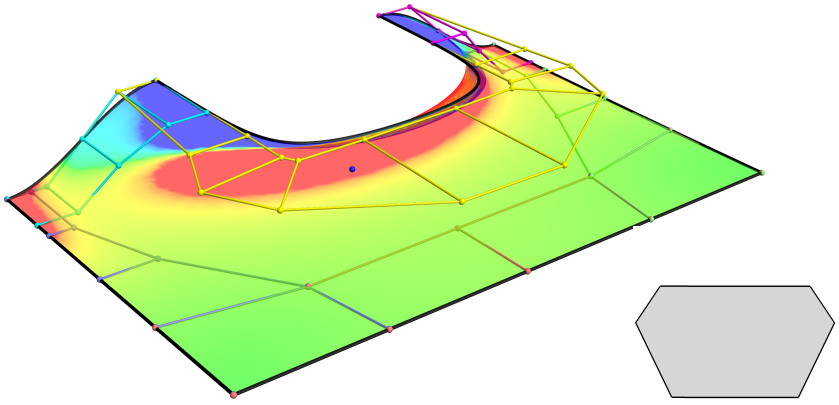
Generalized Bézier patches

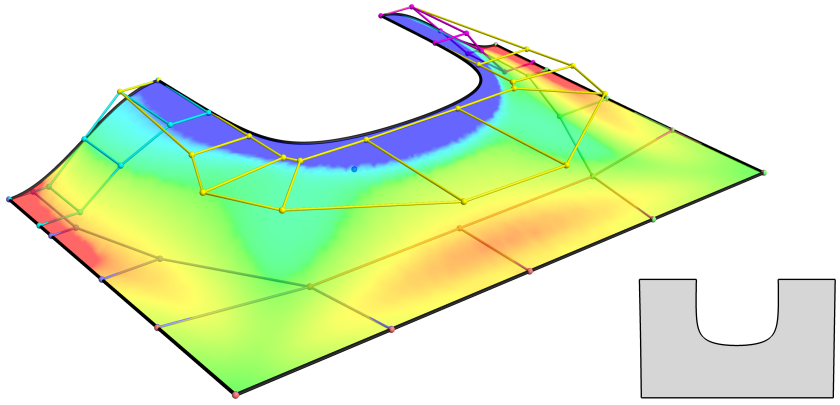


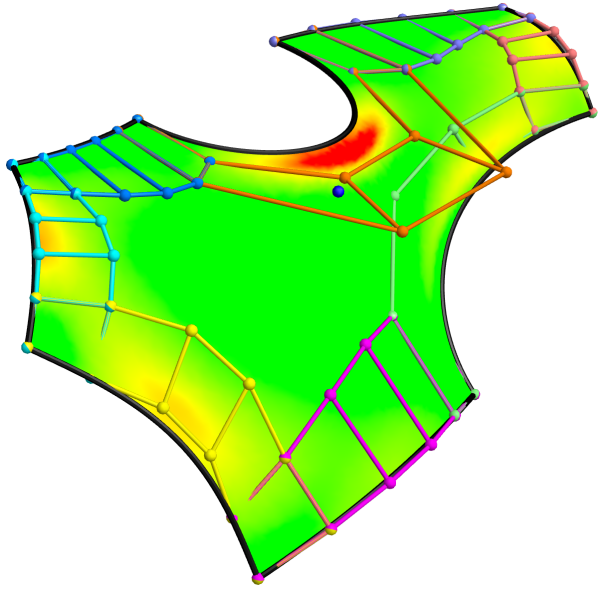
$$\mathbf{S}(u,v) = \sum_{i=1}^{n} \sum_{j=0}^{d} \sum_{k=0}^{(d-1)\div 2} \cdot \mathbf{C}_{ijk} \underline{\mu_{i,j,k}(u,v)} B^d_{i,j,k}(u,v) + \mathbf{C}_0 \cdot \underbrace{B_0(u,v)}_{1-\sum \mu B}$$

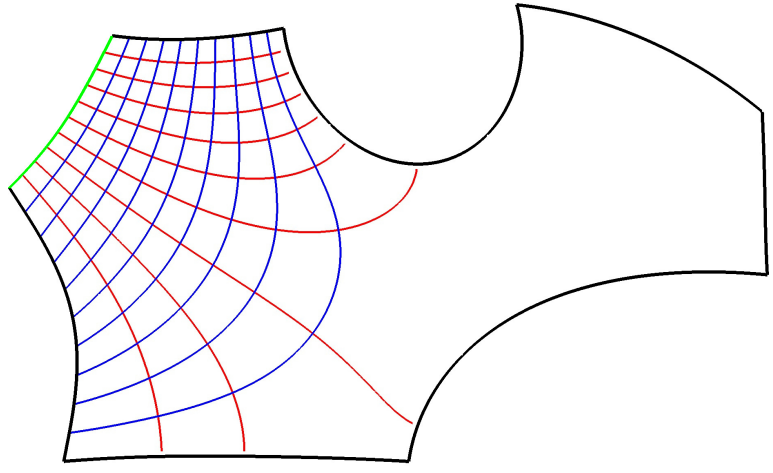
$B^d_{i,j,k}(u,v) := B^d_j(s_i(u,v)) \cdot B^d_k(h_i(u,v))$ with (s_i, h_i) local parameters

Curved domain

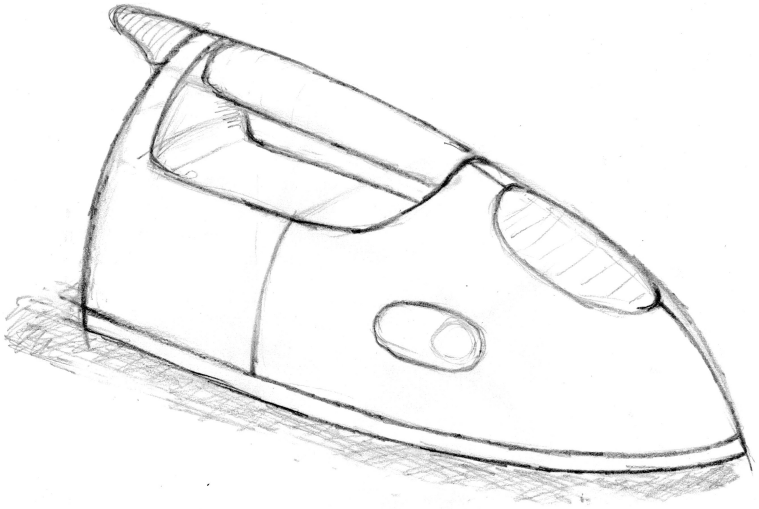


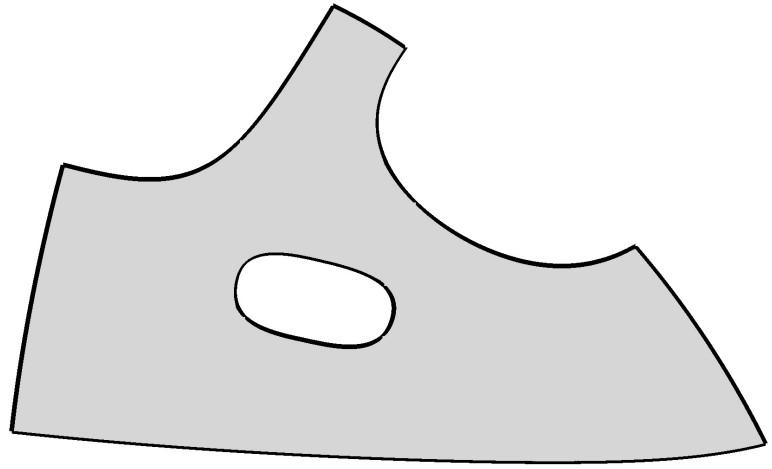


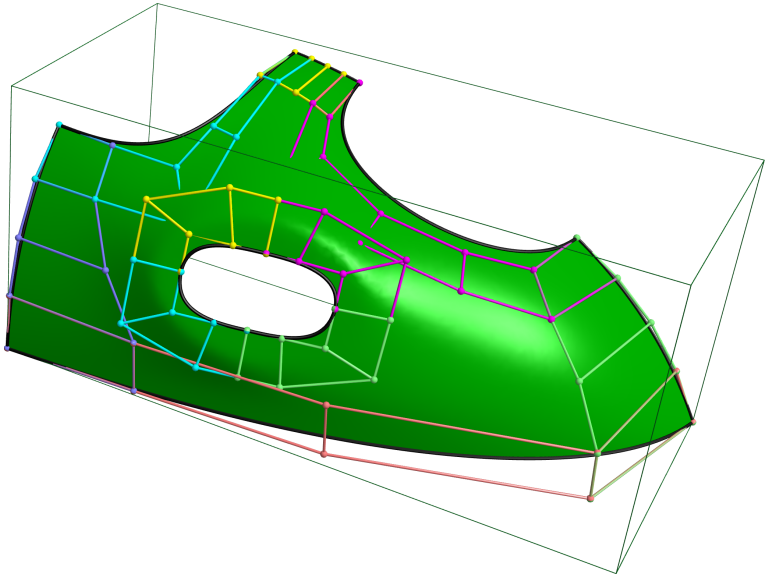


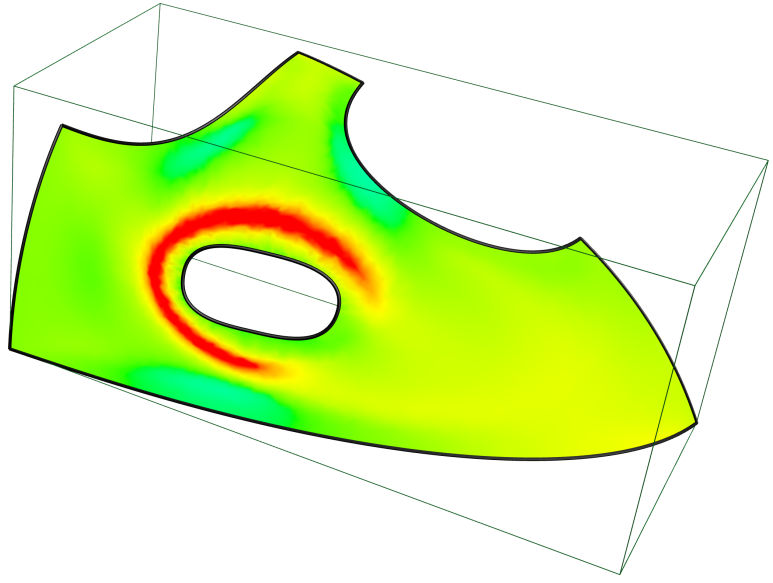


Multi-connected domains

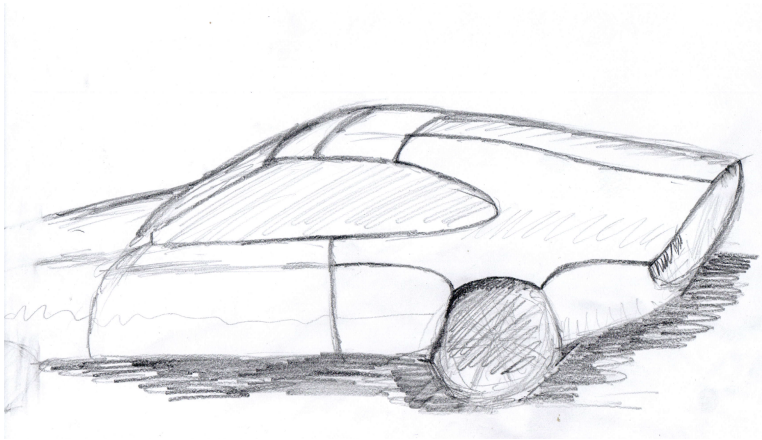


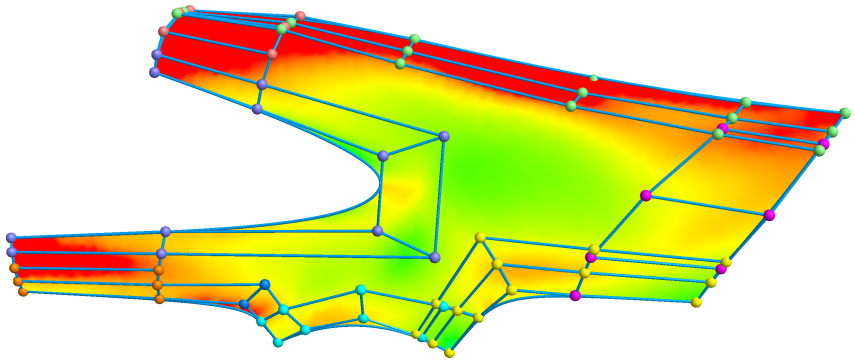


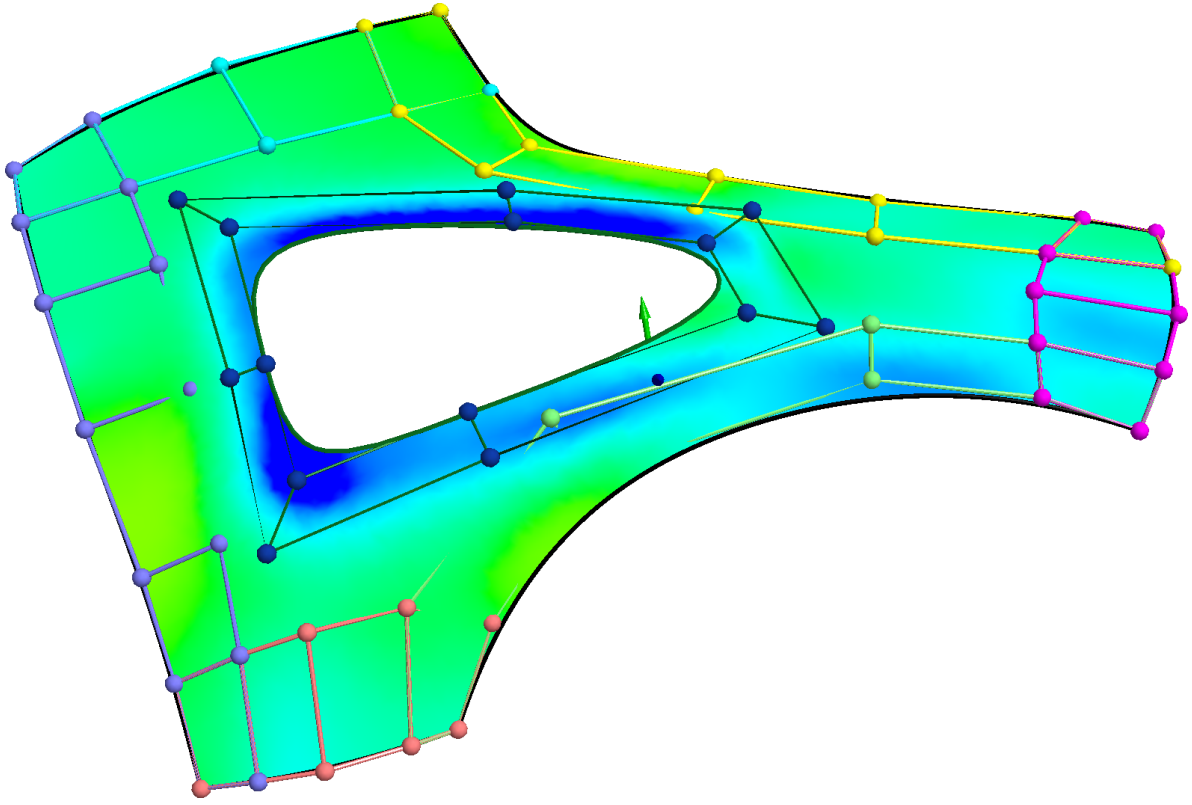




Generalized B-spline patches

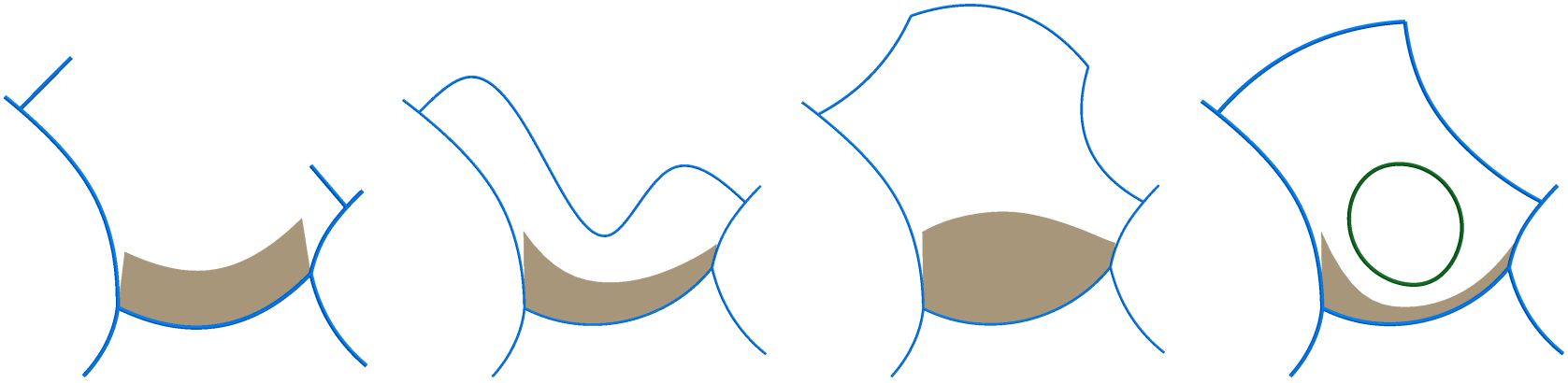


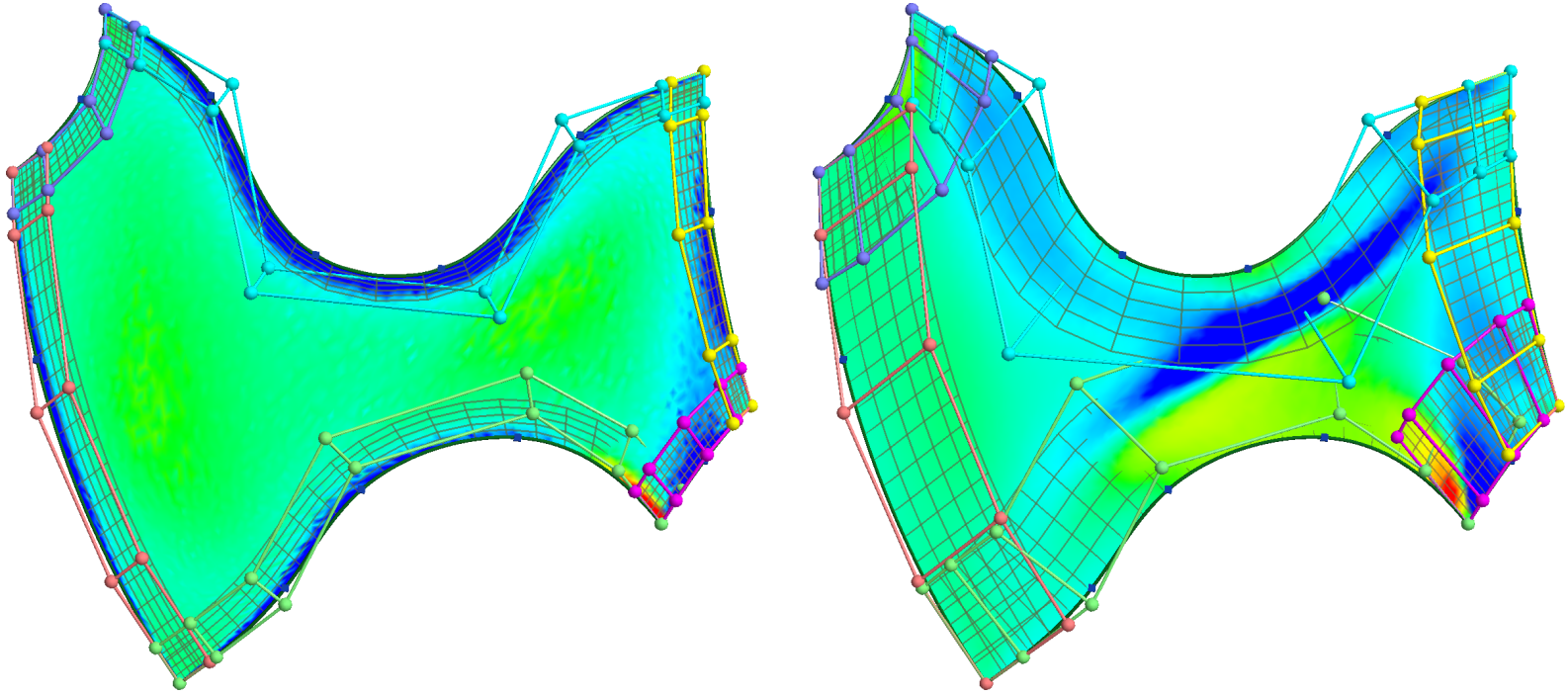




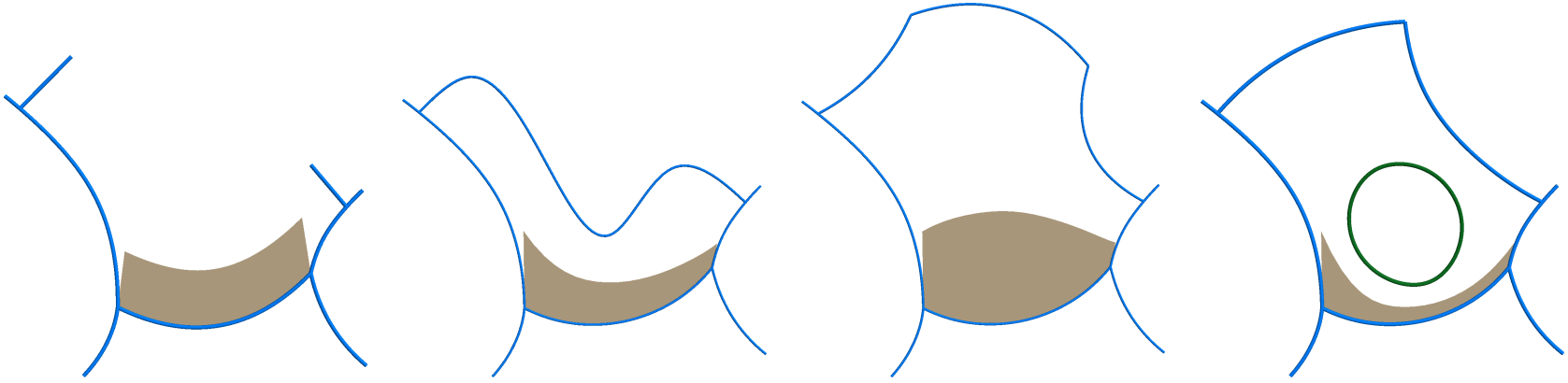
Outline

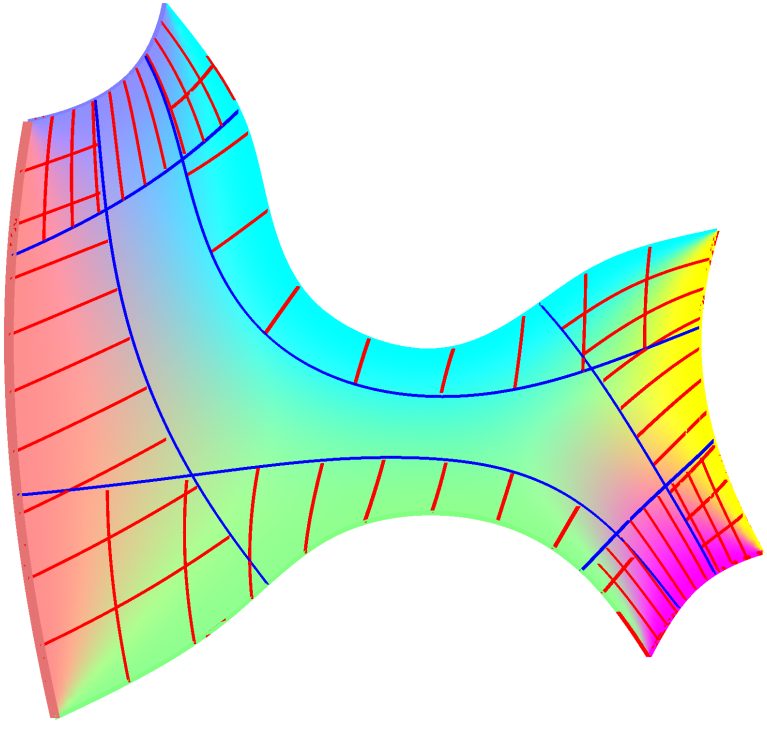
Cross-derivative strength

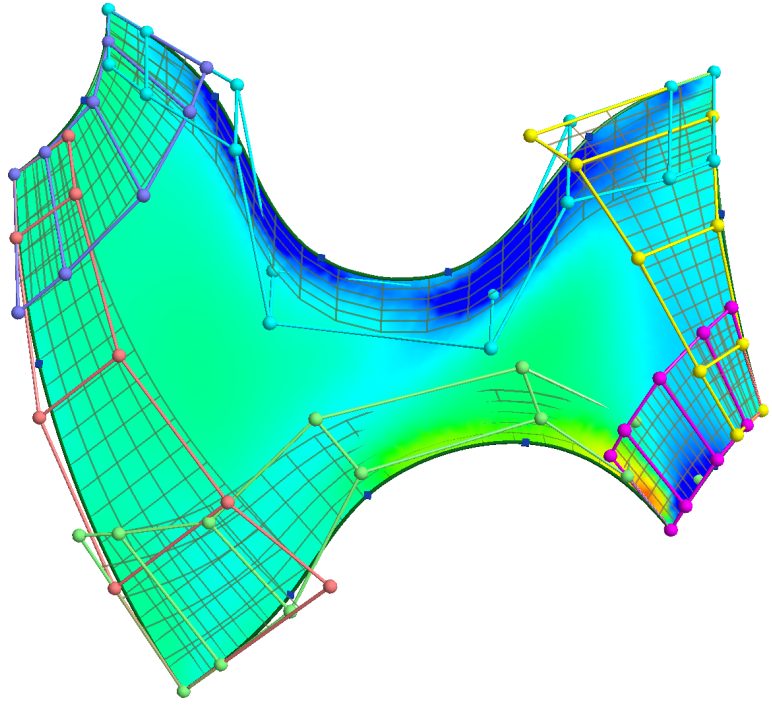




Setting by local parameters

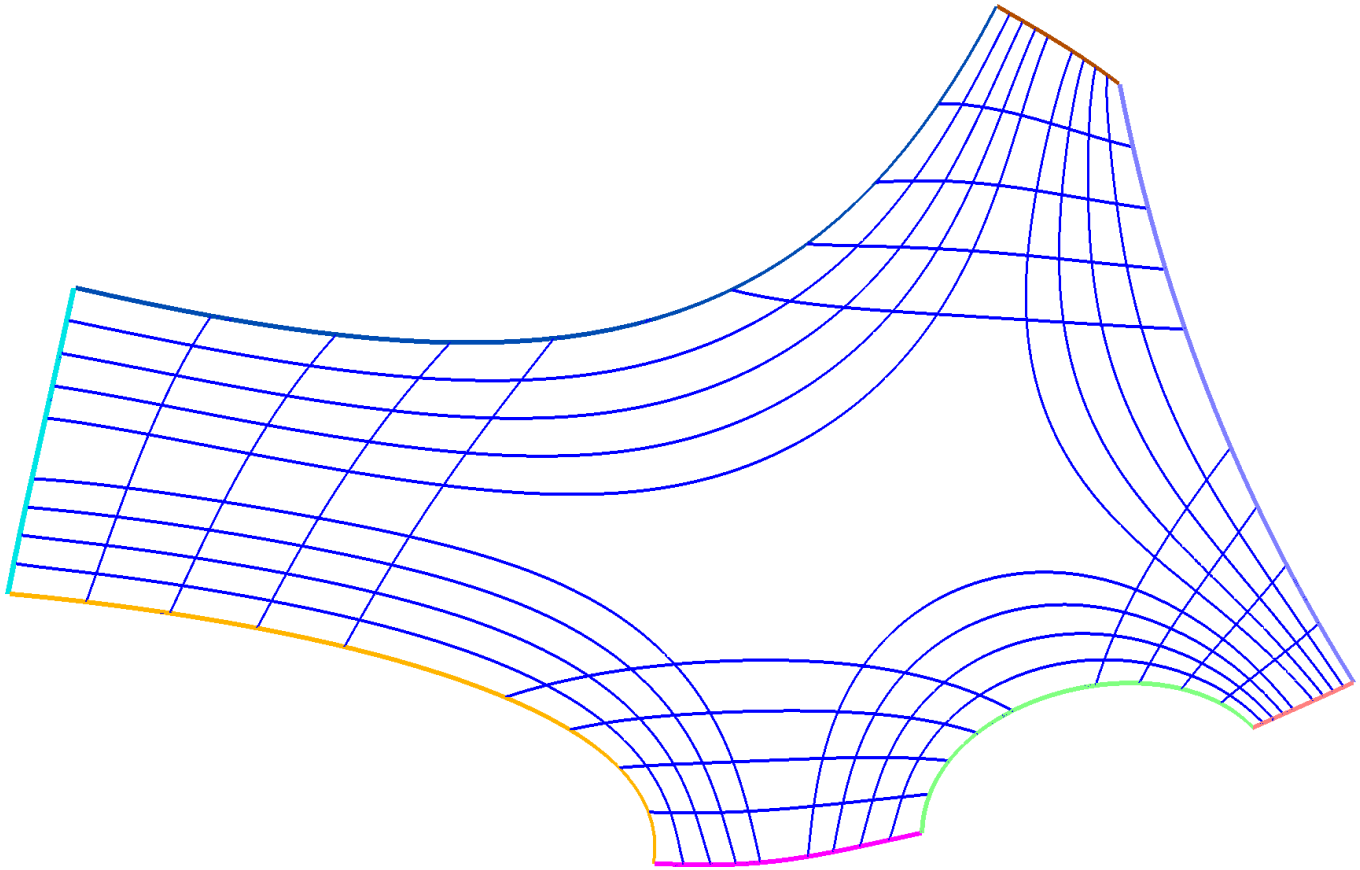




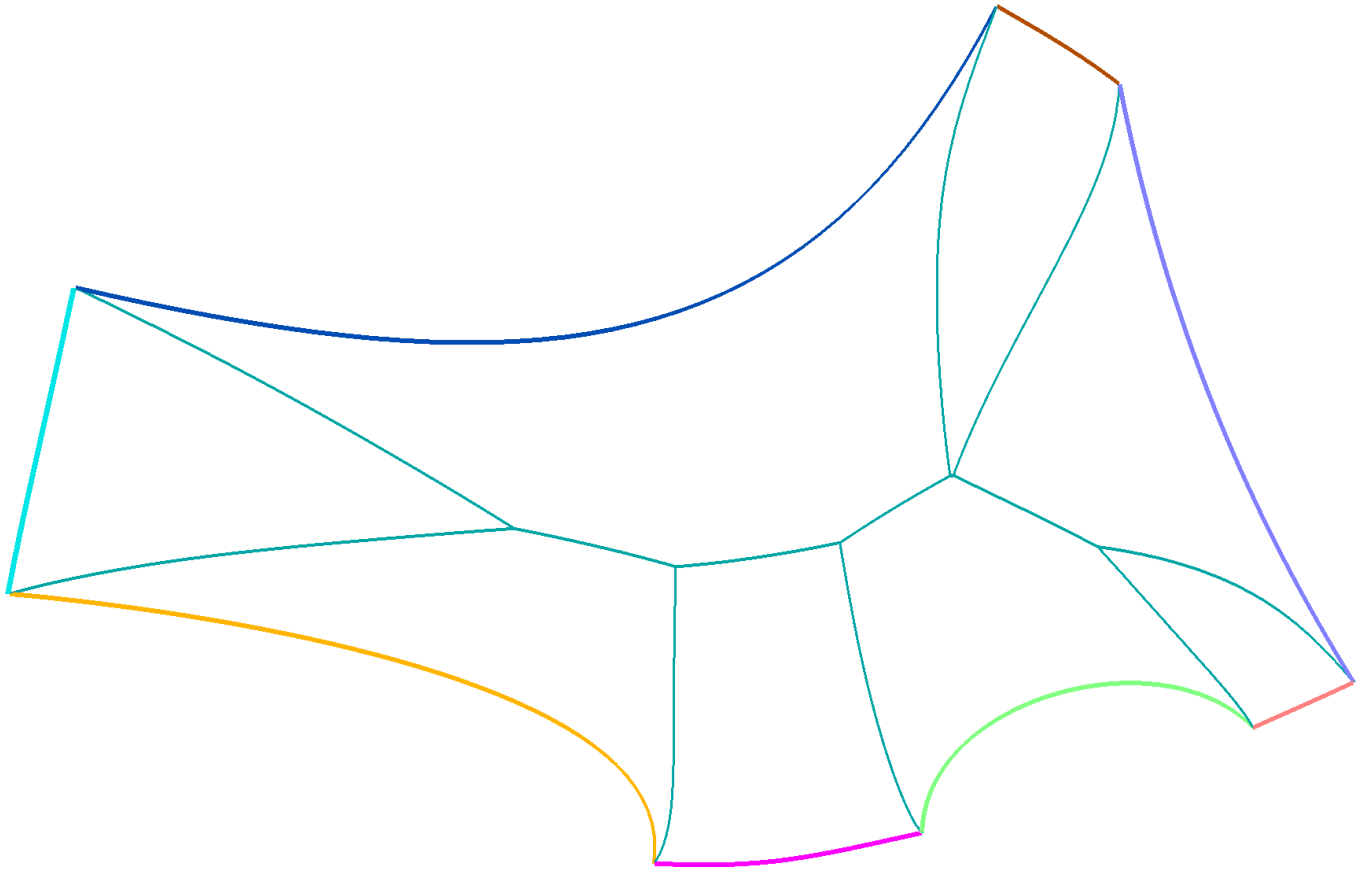


Outline

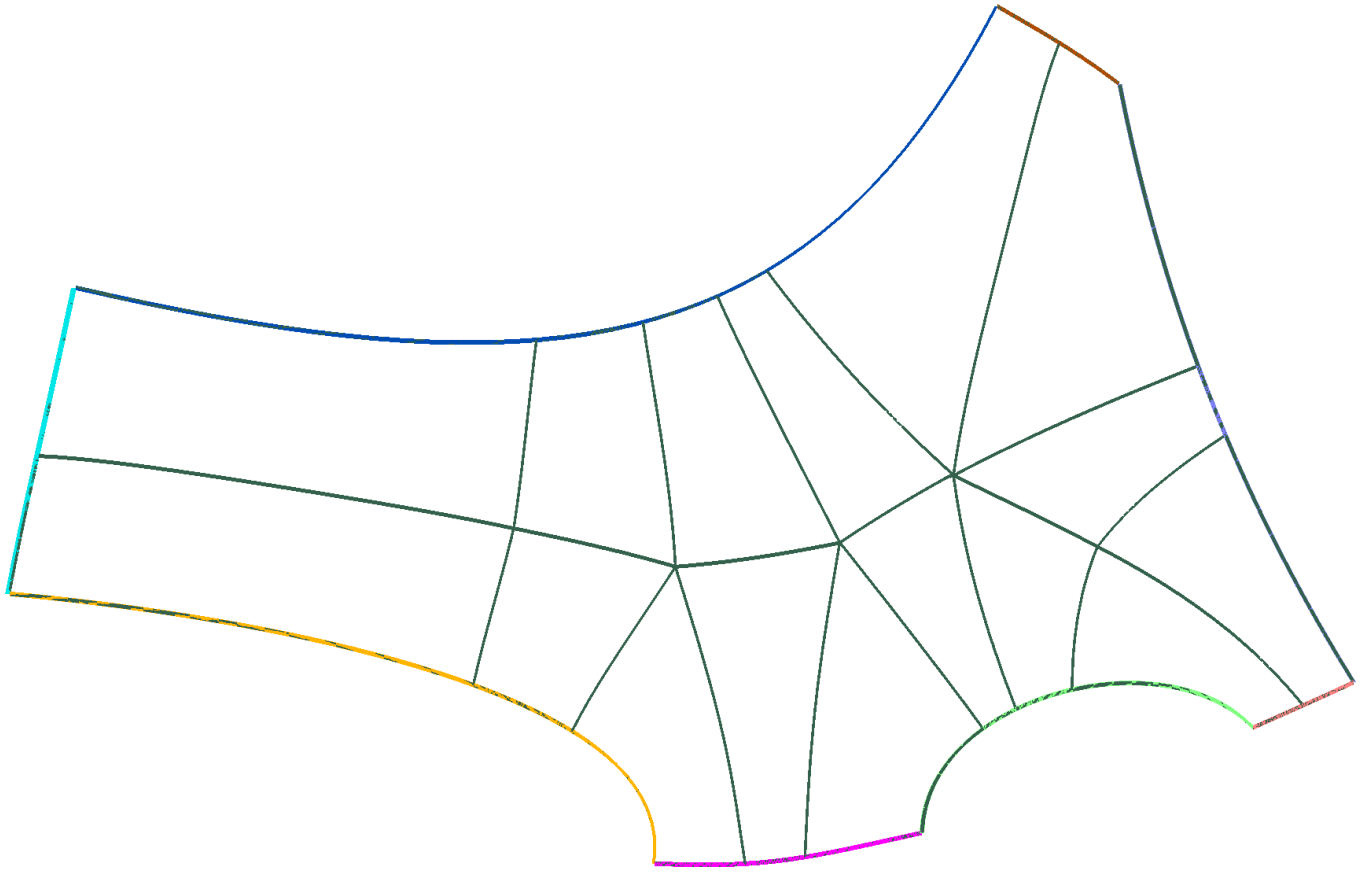
‘Templates’ from medial axis – distance parameters



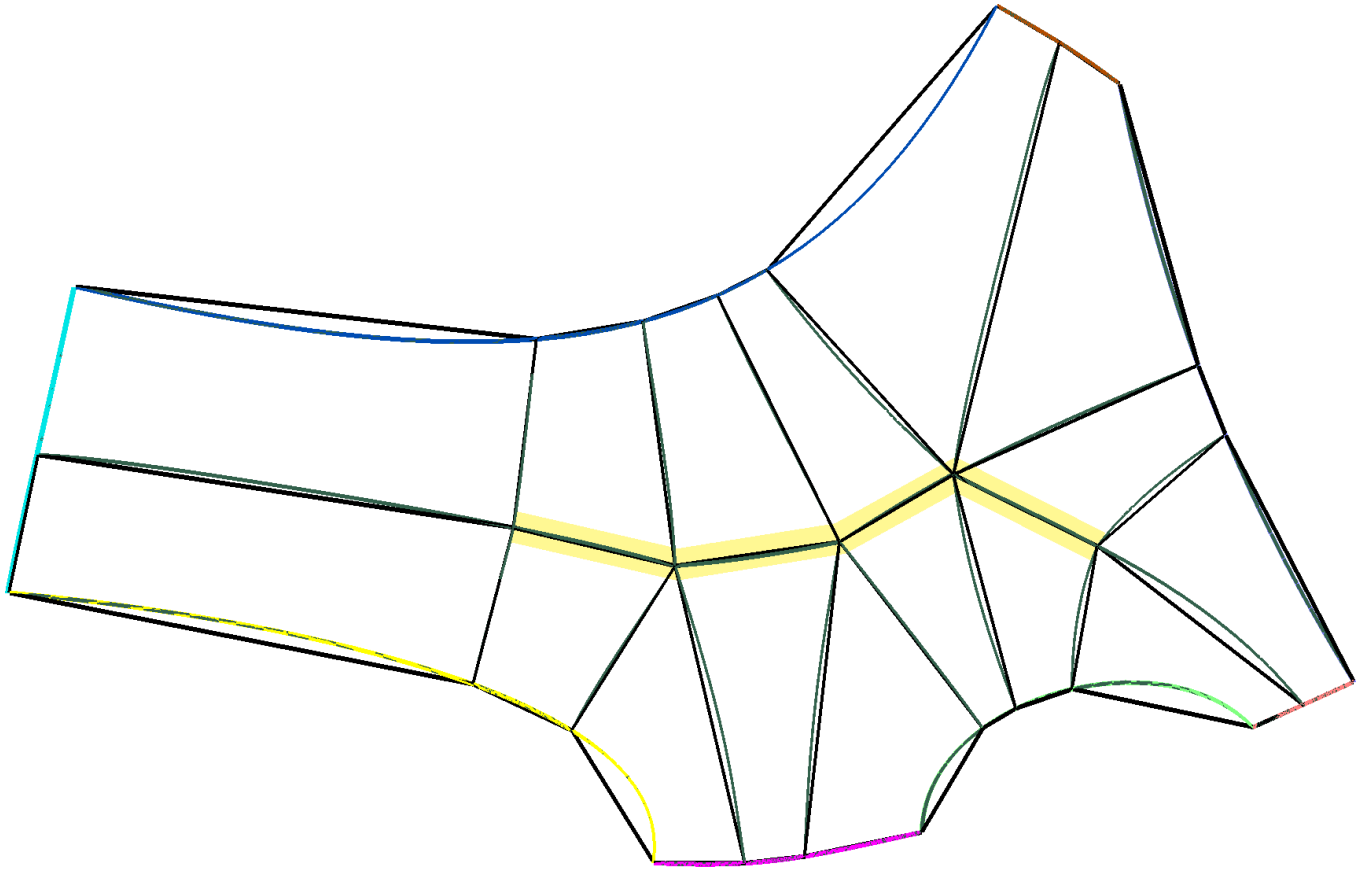
‘Templates’ from medial axis – parametric medial axis



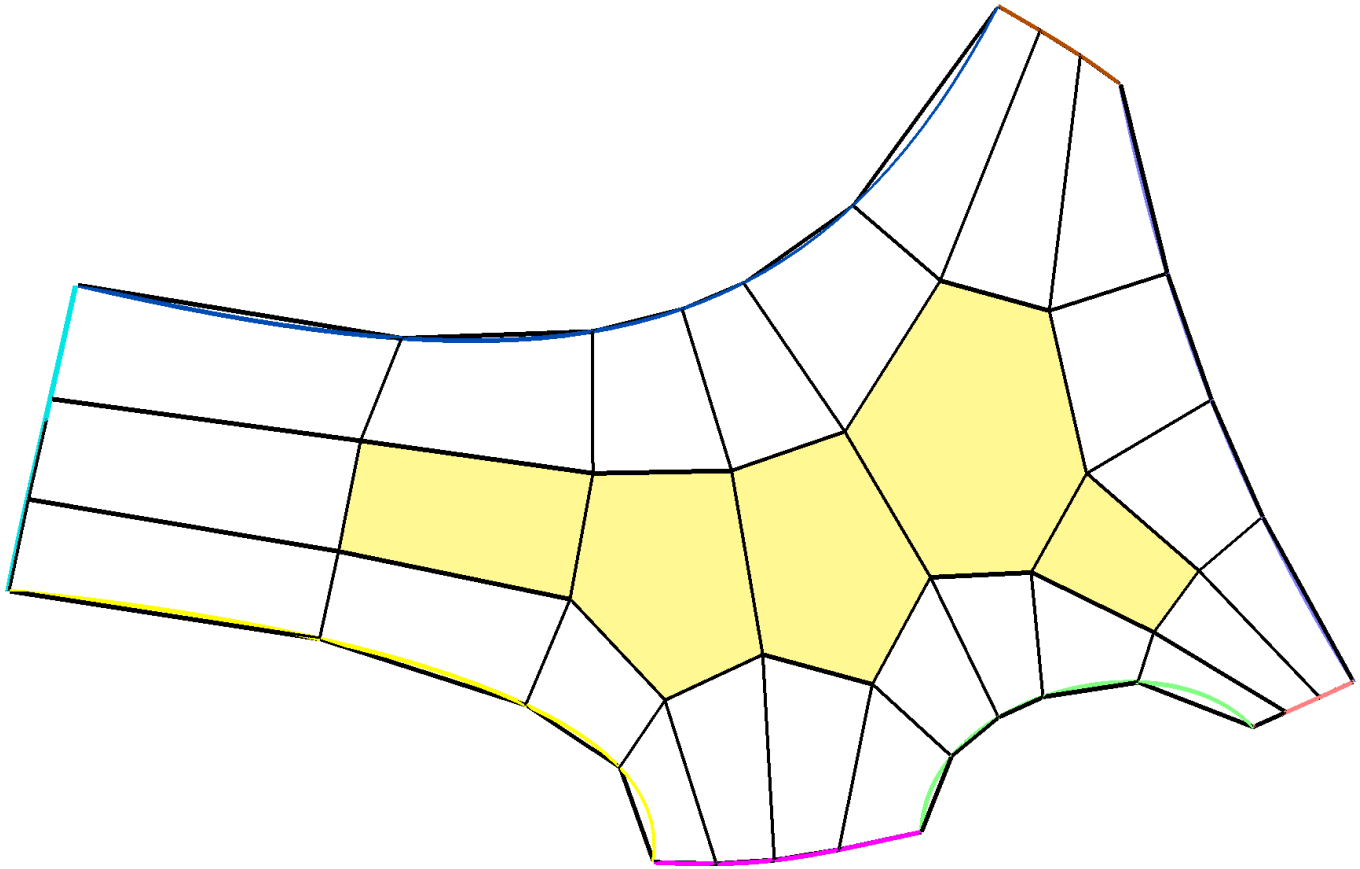
‘Templates’ from medial axis – MAT-based quad structure



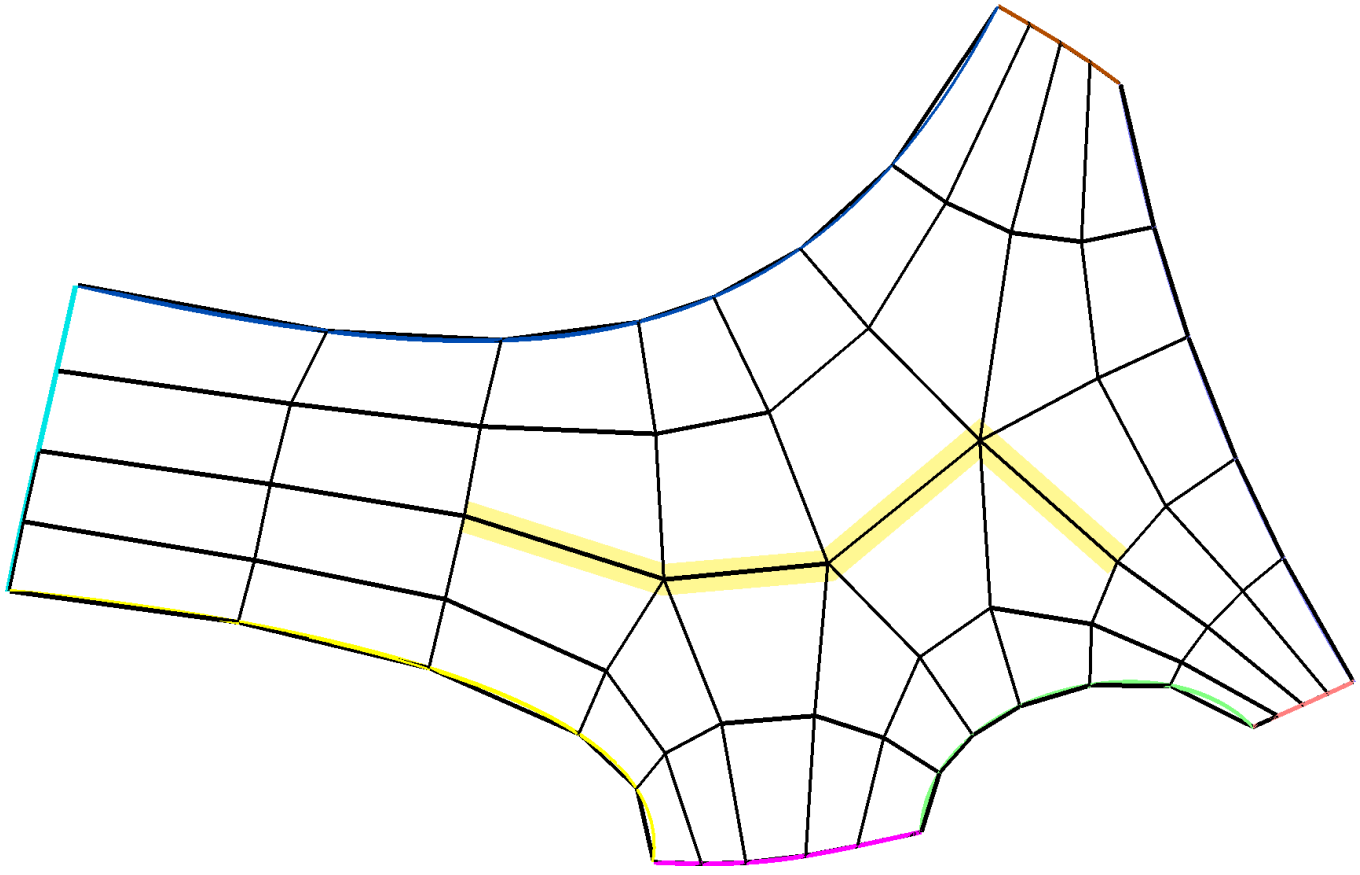
‘Templates’ from medial axis – $T2$ skeleton



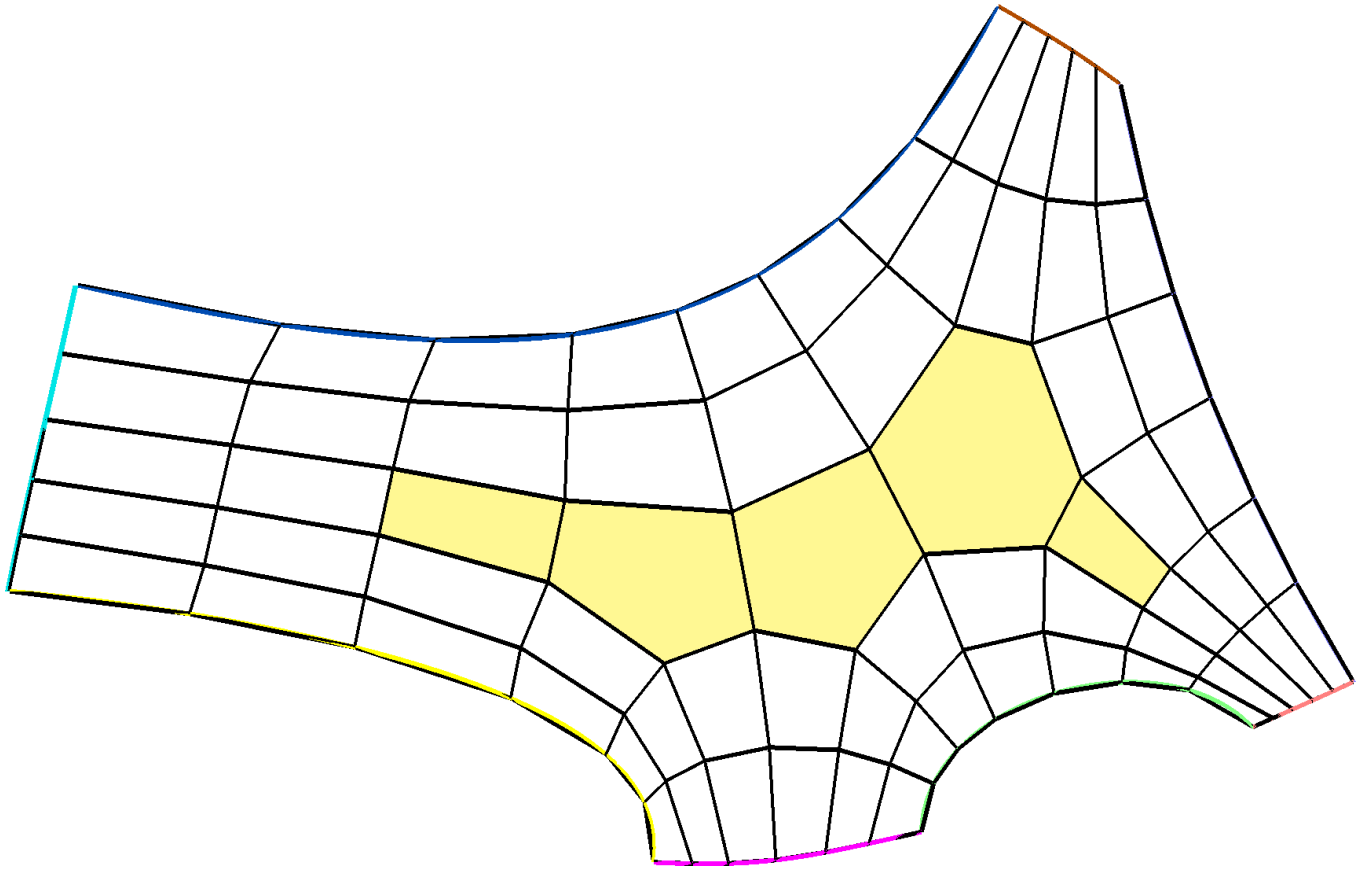
‘Templates’ from medial axis – $T3$ skeleton



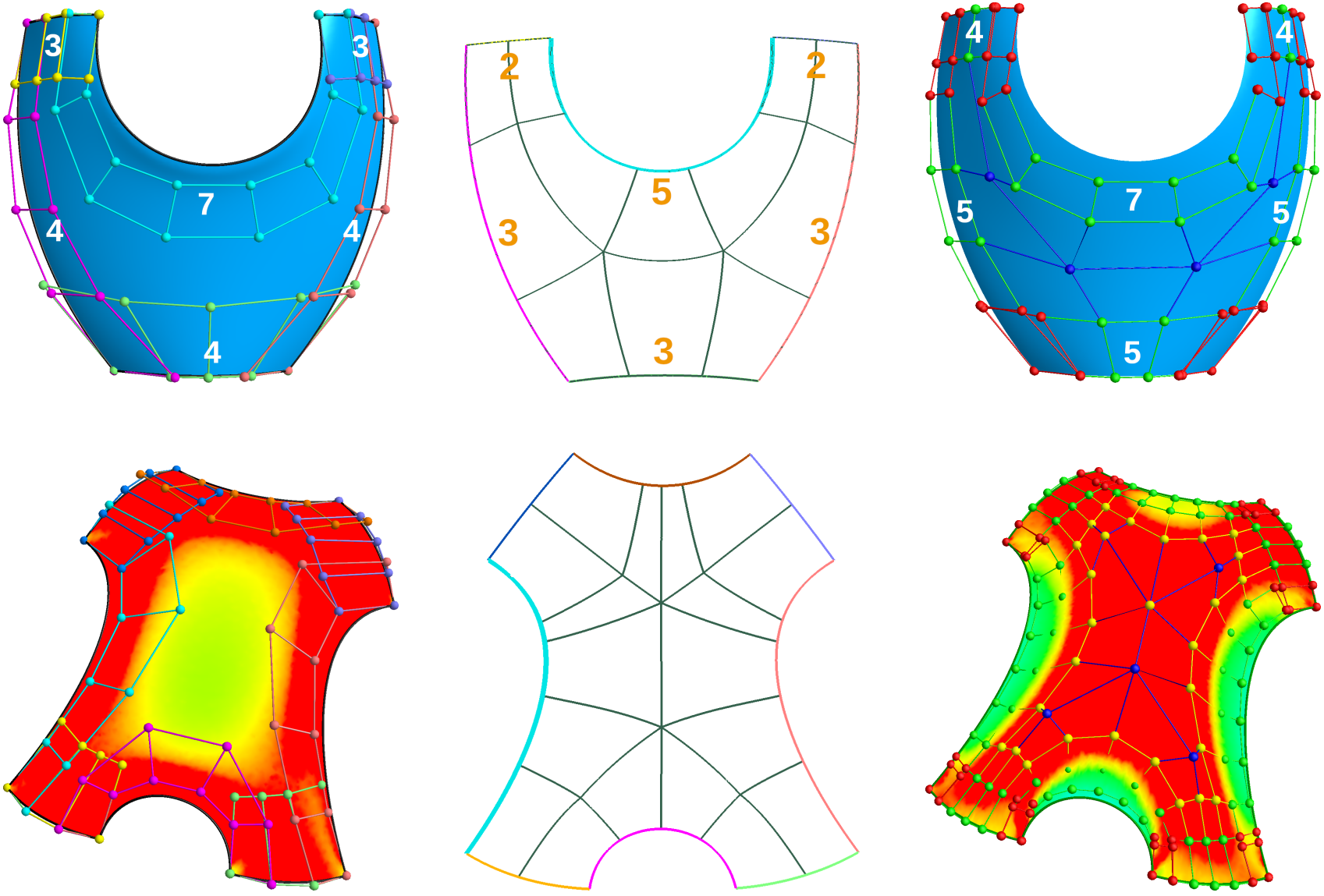
‘Templates’ from medial axis – $T4$ skeleton



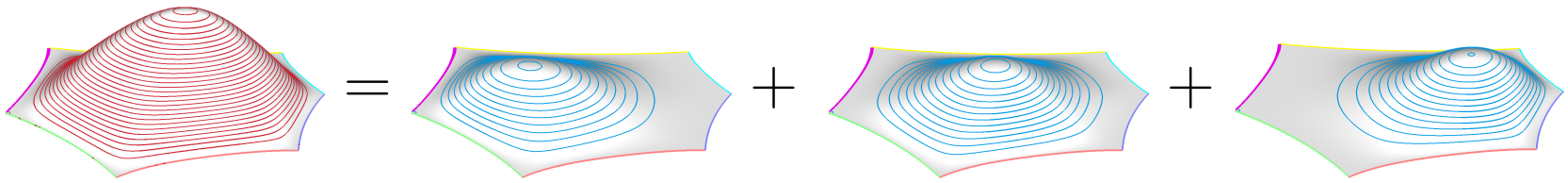
‘Templates’ from medial axis – $T5$ skeleton

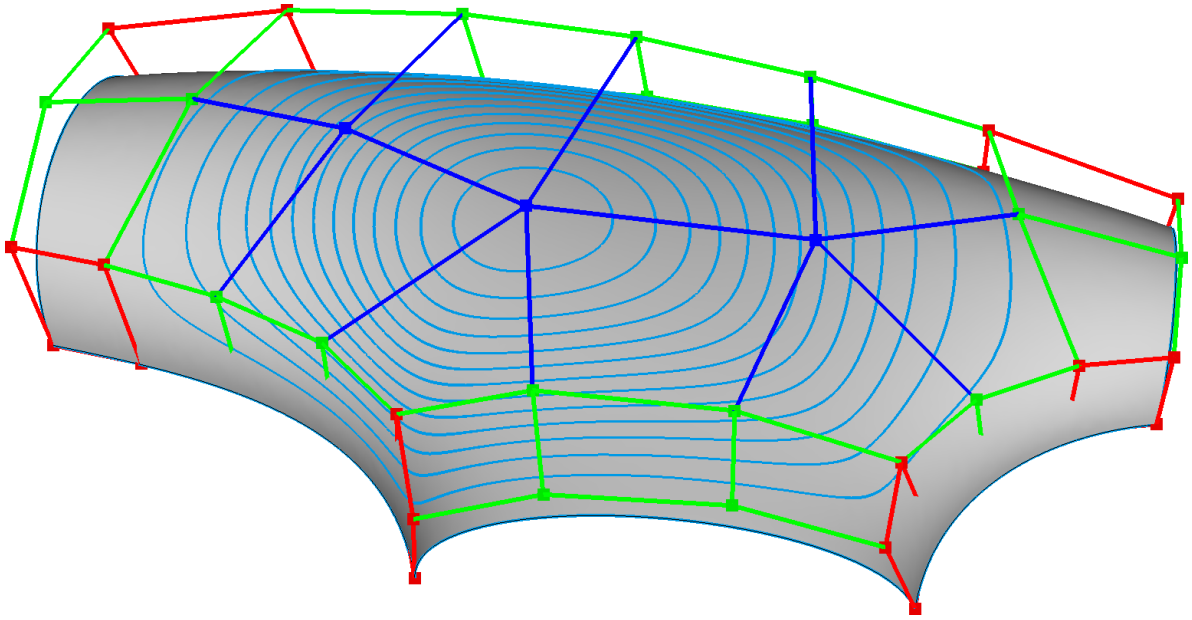


Degree synchronization



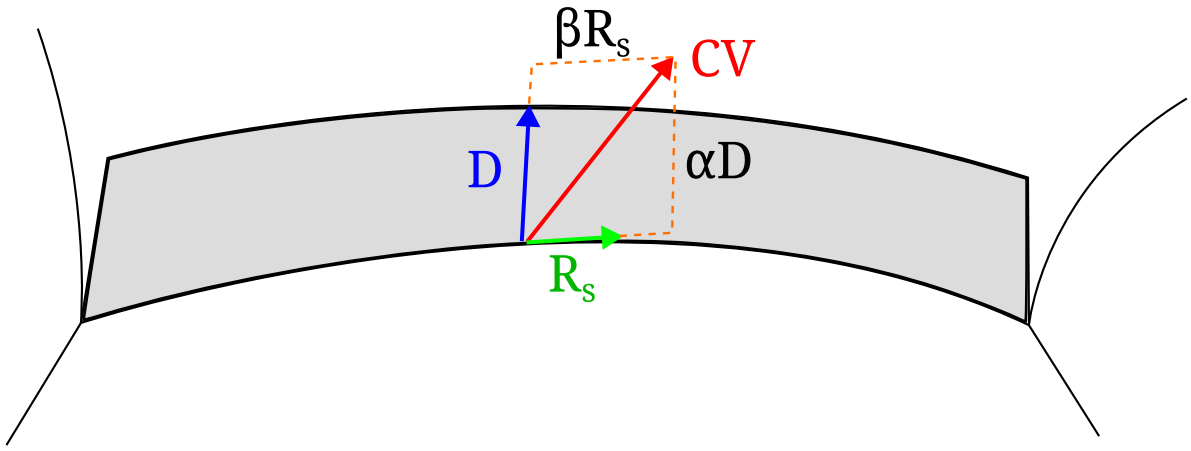
Distributing weight deficiency proportionally

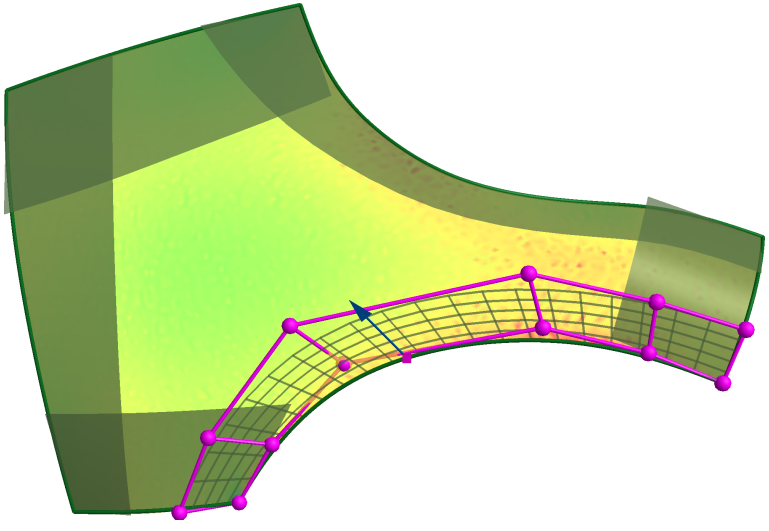


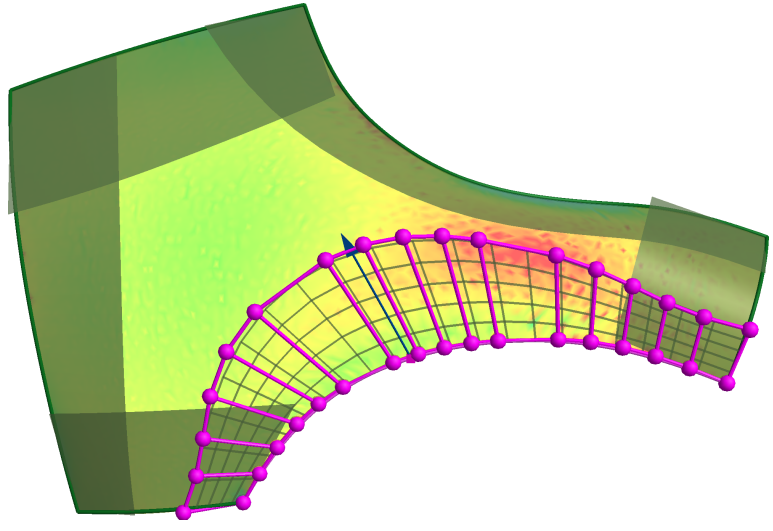


Outline

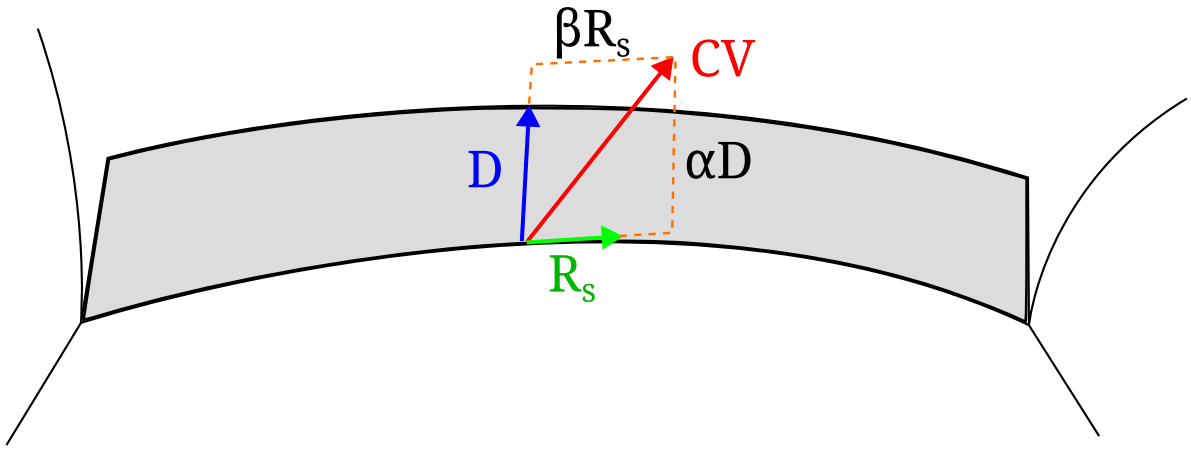
Editing boundaries by control vectors – Exact G^1

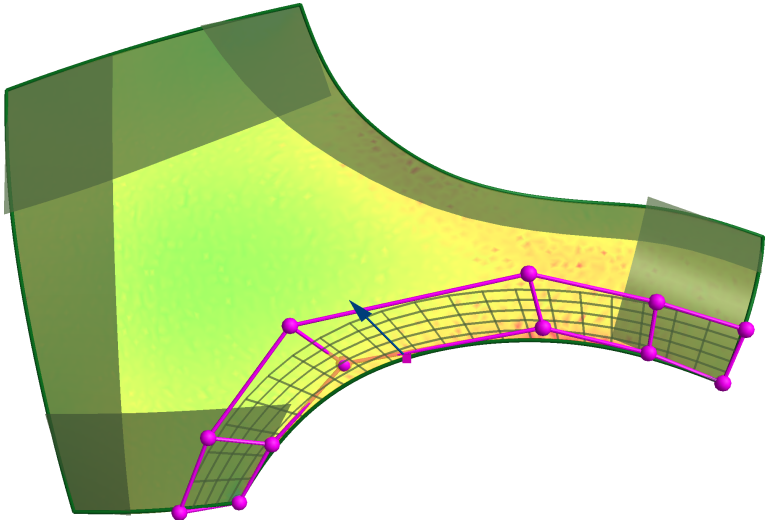


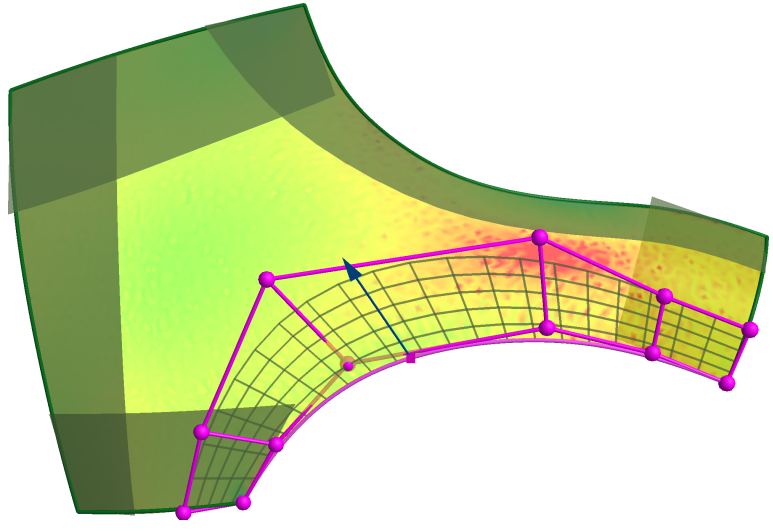




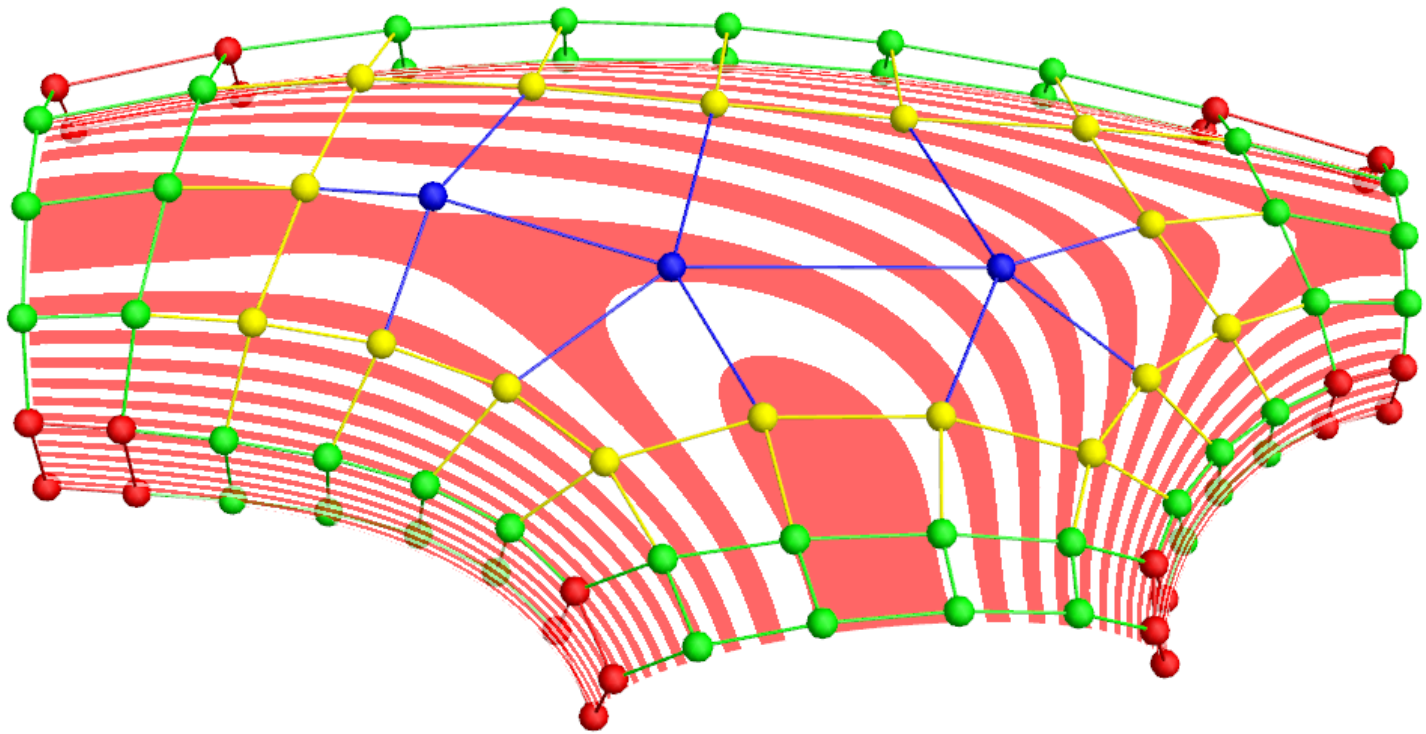
Editing boundaries by control vectors – Approximate G^1



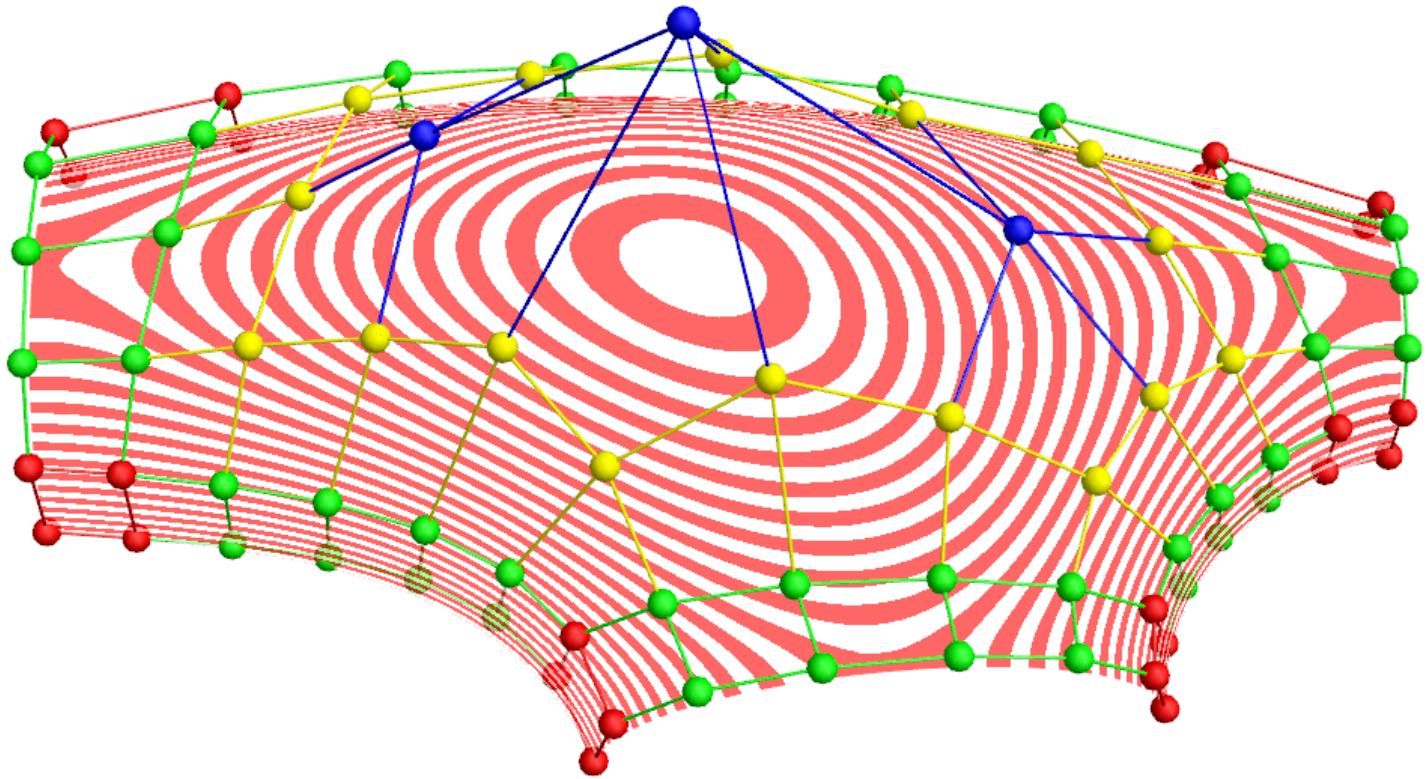




Editing the interior proportionally



Editing the interior proportionally



Outline

Conclusion & future work

- Curved, multi-connected domains
  - Handling of highly curved boundaries
  - Natural cross-derivative lengths
  - MAT $\rightarrow$ interior control structure
- Interior blends
  - Proportional weight deficiency distribution
- Editing
  - Boundary CPs $\rightarrow$ implicitly by control vectors
  - Interior CPs $\rightarrow$ simultaneously with a falloff function

Next: interior control structure for generalized B-spline surfaces

Related papers

1. Multi-sided patch survey

   T. Várady, P. Salvi, M. Vaitkus:
   Genuine multi-sided parametric surface patches – a survey.
   Computer Aided Geometric Design, Vol. 110, #102286, 2024.

2. Modeling with control vectors

   P. Salvi, M. Vaitkus, T. Várady:
   Constrained modeling of multi-sided patches.
   Computers and Graphics, Vol. 114, pp. 86–95, 2023.

3. Independent interior controls

   P. Salvi:
   Intuitive interior control for multi-sided patches with arbitrary boundaries.
   Computer-Aided Design and Applications, Vol. 21(1), pp. 143–154, 2024.

4. MAT-based interior controls

   M. Vaitkus, P. Salvi, T. Várady:
   Interior control structure for Generalized Bézier patches over curved domains.
   Computers and Graphics, 2024. (accepted for SMI'24)

https://3dgeo.iit.bme.hu/