A Phase-field Approach to Variational Hierarchical Surface Segmentation

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In this talk, we will discuss a phase-field model to partition a curved surface into path-connected segments with minimal boundary length as introduced in [1]. Phase-fields offer a powerful tool to represent diffuse interfaces with controlled width and to optimize them in a variational framework. We demonstrate how the multiplicative combination of phase-field functions can be used to effectively compute a hierarchical partition of unity. This induces an associated hierarchy of atlases, whose charts naturally overlap and thus are well-suited for applications such as texture mapping. To ensure connectedness of the charts, we employ a constraint introduced for phase-fields in [3]. Furthermore, we obtain distortion minimizing segmentations via a PDE-constrained optimization approach where the phase-field model allows direct use of Lagrangian calculus. Following [2], the Yamabe equation, which allows computing the distortion induced by segment flattening, is considered as the constraint. This way, we obtain end-to-end diffuse formulations of variational problems in surface segmentation that are straightforward to treat computationally. Various examples will illustrate the flexibility and robustness of this approach.

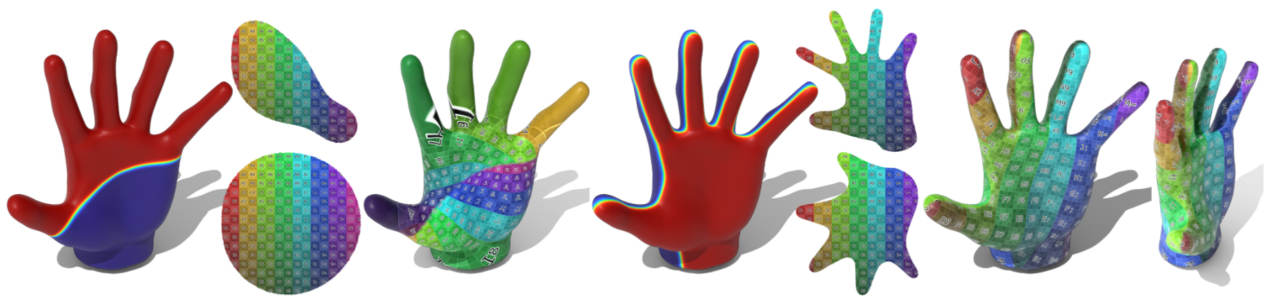

Figure 1: Our phase-field approach produces segments with diffuse interfaces, shown as red to blue colormap, by solving a variational problem. From this, we produce charts, shown are their images in the plane, and use them to map textures to the surface. However, the charts exhibit high distortion when only using the perimeter as objective (left). Thus, we minimize the distortion using the Yamabe equation as PDE-constraint (right).

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References

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[3] P. Dondl, A. Lemenant, and S. Wojtowytsch. Phase Field Models for Thin Elastic Structures with Topological Constraint. *Archive for Rational Mechanics and Analysis*, 223, pages 693–736, 2017.