

PhD Position: Generative Design for Faceted Geometries

We, the BMW Group, offer an interesting, multidisciplinary PhD position in the field of generative design in form-finding with focus on faceted geometries and the mathematics enabling them. The research of the parametric dependencies across the geometry elements is the key to successfully create a complex surface 3D structure including all the industrialization requirements. With a new understanding of these mathematical relations we are going to expand our access to 3D geometries and transform the designer's vision in a both technically valuable and aesthetically inspiring surface language.

Be part of it.

[BMW Portal, Job ID 31989](#) or this [PDF at TU Wien](#)

Tasks:

- Methodic development of facet-based geometry interacting with its properties:
 - Properties: i.e. angles, proportions, size, space availability for fillets or offsets.
 - Facet forms: starting with triangles, extended to n-sided facettes in a later phase of the research.
 - Dimensionality: on surfaces at first and extended method into 3D volumes in a later phase of the research.
- Interaction and compatibility with BMW generative design methods in grasshopper.
- Implementation of innovative design models of parametric and generative/algorithmic form-finding in Rhino/Grasshopper or Catia V5 across all phases of the shape-finding process.
- Support of the Generative Design Team in tool and method development.

Methods and goals:

- Formulation of geometric energies to be minimized with the goal to change the quality of the net in a favorable direction.
- Optimization of the preferred dihedral angles of the net. Implementing options for user defined angle distribution over the surface, e.g., by prescribing a function or by prescribing attractors or by selecting individual edges. We keep in mind the goal of an intuitive and user-friendly input method.
- Optimization of proportions and ratios between areas of neighboring faces, areas of faces around vertices, lengths of edges of individual triangles, lengths of edges emanating from individual vertices, etc.
- Application of Geometric quality measures (like angles, areas, lengths, etc.) prescribed by target values and/or average values and/or within minimum-maximum ranges.
- Methods to achieve geometric energy minimization based on optimization and interactivity (real time reaction to user inputs).

Technical requirements:

- Master Degree in mathematics, Computational Design, Physics, Computer Science or Software Development
- Knowledge in one or more of the following areas:
 - Programming languages C#- and Python, simulation and optimization methods, CAS/Strak free-form surface design, manufacturing processes, McNeel Rhino/Grasshopper.
- Fluent German and English skills.

Links to recent research topics

- [1] Visual appearance of "un-smoothness" in opposition to visual appearance of smoothness of polyhedral surfaces in [6, 7].
- [2] Relations to discrete mean curvature notions, cf. [8].
- [3] Feature enhancement methods in geometry processing.

References

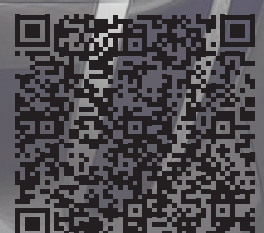
- [1] The Computational Beauty of Nature: Computer Explorations of Fractals, Chaos, Complex Systems, and Adaptation
- [2] Generative Design: Visualize, Program, and Create with JavaScript in p5.js
- [3] Math Art: Truth, Beauty, and Equations
- [4] The Nature of Code: Simulating Natural Systems with Processing
- [5] Mathematical Models for Biological Pattern Formation
- [6] F. Günther, C. Jiang, and H. Pottmann. Smooth polyhedral surfaces. *Advances in Mathematics*, 363, 2020.
- [7] D. Pellis, M. Kilian, F. Dellinger, J. Wallner, and H. Pottmann. Visual smoothness of polyhedral surfaces. *ACM Trans. Graphics*, 2019. Proc. SIGGRAPH.
- [8] J.M. Sullivan. Curvatures of smooth and discrete surfaces. In A.I. Bobenko, J.M. Sullivan, P. Schröder, and G.M. Ziegler, editors, *Discrete Differential Geometry*, pages 175-188. Birkhäuser Basel, Basel, 2008.



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