PhD Position: Generative Design for Faceted Geometries

We, the BMW Group, offer an interesting, multidisziplinary PhD position in the field of generative design in form-finding with focus on facetted 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.

Dr. Prof. Helmut Pottmann, TU Wien
Prof. Ass. Christian Müller, TU Wien
Florian Rist, GCD TU WIEN

Dipl. Ing. (FH) Daniel Häseker, BMW Group
Dr. Majid Hojjat BMW Group

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