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Surface mesh smoothing and improvement strategies for free-form shapes in industrial and academic applications

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Since many years, a wide range of stable, efficient and robust 2D meshing algorithms based on triangular and quadrilateral elements is available [1, 2]. These 2D-based algorithms can be easily extended to curved surfaces in space by means of proper geometric mappings. However, poor parameterizations can affect the mesh quality and robustness of the meshing algorithms dramatically. The 2D meshing algorithms in parametric space can be enriched by approximations of real lengths and angles in 3D space [3]. Nevertheless, this strategy can be pushed to its limits by very poor parameterizations and highly curved NURBS-based shapes especially when multi-patch descriptions are used. Unfortunately, critical parameterization might be difficult to be visually detected in the geometric model and its improvement can be tedious, time consuming, and not straight forward within a CAD program.

This contribution will give an insight into the challenges for 2D-based surface meshing algorithms in the field of civil engineering due to poorly parameterized free-form shapes. Industrial and academic examples will be presented, originating from complex and extravagant designs in modern architecture or from shape optimization of tent structures. Available mesh smoothing and improvement strategies [4, 5] will be presented to deal with these critically parameterized free-form surfaces. Laplacian smoothing and distortion or angle optimization techniques will be presented with respect to their performance and applicability on real life test cases. Specifically, we investigate the effect of stabilizing methods like proper sub-mesh selection or displacement constraints and propose strategies for their improvement.

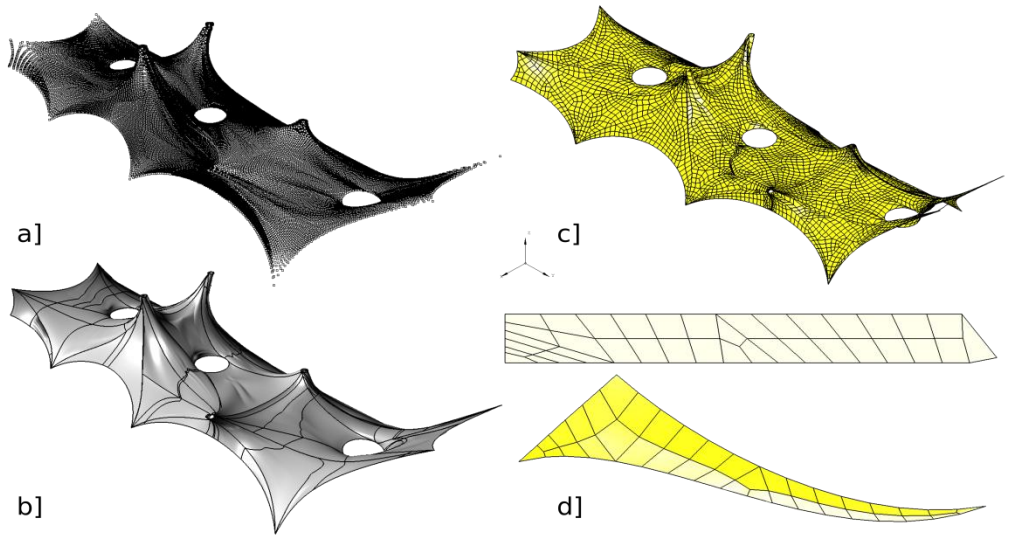

Figure 1: **a**) Point-wise surface representation of tent structure. **b**) Multi-patch NURBS surface description. **c**) Quadrilateral Finite Element mesh. **d**) Comparison of parametric and 3D space.

REFERENCES

[1] S. J. Owen, A Survey of Unstructured Mesh Generation Technology. *Proceedings 7th Intern. Mesh. Roundtable*, pp. 239–267, 1998.

[2] E. Rank, M. Schweingruber and M. Sommer, Adaptive mesh generation and transformation of triangular to quadrilateral meshes. *Communications in Numer. Meth. Engng*, Vol. **9**, pp. 121-129, 1993.

[3] J.R. Tristano, S.J. Owen and S.A. Canann, Advancing front surface mesh generation in parametric space using a Riemannian surface definition. *Proceedings 7th Intern. Mesh. Roundtable*, pp. 429-445, 1998.

[4] Z. Chen, J.R. Tristano and Wa Kwok, Combined Laplacian and optimization-based smoothing for quadratic mixed surface meshes. *Proceedings 12th Intern. Mesh. Roundtable*, pp. 361-370, 2003.

[5] X. Roca, A. Gargallo-Peiró and J. Sarrate, Defining Quality Measures for High-Order Planar Triangles and Curved Mesh Generation. *Proceedings 20th Intern. Mesh. Roundtable*, pp. 365-383, 2012.