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Gradient-based shape optimisation with CAD in the loop: imposition of assembly constraints

Salvatore Auriemma*[1], Mladen Banovic[2], Andrea Walther[2], Orest Mykhaskiv[3] and Jens-Dominik Müller[3]

[1] OpenCASCADE, 1 Place des Frères Montgolfier 78280 Guyancourt, France,
salvatore.auriemma@opencascade.com, `https://www.opencascade.com/`
[2] Universität Paderborn, Warburger Str. 100, 33098 Paderborn, Germany,
mladen.banovic@math.uni-paderborn.de, `https://www.uni-paderborn.de/`
[3] Queen Mary University of London, Mile End Road, London, E1 4NS, UK,
o.mykhaskiv@qmul.ac.uk, `http://www.qmul.ac.uk/`

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CAD-based shape optimisation with gradient-based methods, requires the gradient of the objective w.r.t. the CAD model parameters which can be computed in two parts. The *CFD sensitivity*, the gradient of the objective w.r.t. the surface mesh points, is efficiently evaluated using adjoint CFD methods. The *CAD sensitivity*, the gradient of the surface mesh points w.r.t. the CAD design parameters, is not computed by standard CAD systems. In order to compute exact CAD sensitivities, the group has achieved a breakthrough by applying Automatic Differentiation to the open-source CAD kernel Open Cascade Technology (OCCT) [1]. The resulting framework enables to use the wide range of geometric algorithms available in OCCT within a gradient-based optimisation loop.

We use the differentiated intersection algorithms of OCCT/AD to impose assembly constraints for the optimisation of the TU Berlin TurboLab Stator with objective to minimise total pressure loss. Most constraints such as leading/trailing edge radii and chord length can be directly included in the CAD parametrisation. A more challenging constraint is to maintain blade volume to include 4 cylindrical mounts.

The particular issue is to construct an auxiliary model of intersection which provides a differentiable signed intersection function.mounts. The function implementation needs geometric predicates that can robustly handle limit cases such as tangency. The paper will present a range of 2D and 3D algorithms, discuss their properties and evaluate the robustness of their implementation in CAD. Shape optimisation of the TUB stator benchmark with the candidate algorithms will be demonstrated.

REFERENCES

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