CAD-Free Soft Handle Parameterization for Adjoint-Based Optimization Methods

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The aim of this article is to develop and validate a CAD-Free parameterization tool which is necessary in the Adjoint-based optimization methods in order to perform an optimization cycle. The Rigid Motion Mesh morpher ensures an as-rigid-as-possible motion by minimizing a distortion metric. This morpher lacks of parameterization of the boundaries, so the CAD-Free parameterization tool, which is compatible with this existing in-house mesh morpher, is responsible for the displacements of the mesh in such way that the resulting mesh is a compromise in between the prescribed or target velocities and the smoothness requirements of the mesh motion. In this article, CAD-Free Soft Handle Parameterization for Adjoint-Based Optimization Methods is presented and will be tested in some classical optimization test cases.

I. Introduction

In adjoint based shape optimization problems, morphing (or mesh deformation) is an efficient way (as opposed to re-meshing) to apply the necessary shape changes right after the sensitivities have been computed.

The Rigid Motion Mesh Morpher[1] and its new updated version,[2] is a mesh-less method and tool which gracefully propagates the movement of the boundaries (surface mesh) to the internal nodes of the mesh (volume mesh), ensuring an as-rigid-as-possible motion. This morpher needs to be supplemented with a parameterization of the boundaries in order to conduct the optimization process in a practical way. CAD-free[3] and CAD-based parameterization are the two options. In this paper, CAD-free parameterization will be investigated, because it is versatile as it does not require any connection with a third party platform such as CATIA, Open Cascade etc. Since the output of the discrete adjoint method are the sensitivities computed with respect to the node coordinates and because of the limited resolution in the discretization schemes, it is a common case that the calculated sensitivities include numerical noise. If used directly to morph the mesh, the resulting surfaces might not be acceptable. The CAD-free soft handle parameterization tool, proposed in the present study, aims to keep a rich design space while enforcing smoothness to the shape.

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The handles are selected based on an appropriate sampling of the surface nodes, and a target velocity value is defined for each handle. Shape changes are thus driven by minimizing the difference between target and actual handle velocities, whilst ensuring that smoothness requirements are enforced. The efficiency of this approach will be demonstrated on some classical optimization test cases.

II. Results

Preliminary results of the CAD-Free Soft Handle Parameterization tool do show the utility of this tool. It has been implemented in a tipgap test case. In this case there is a gap between a blade and its shell. A displacement is applied to the blade, which includes numerical noise. The Rigid Motion Mesh Morpher and its adaptive parameterization tool are used to deform the blade. Some figures that follow, demonstrate the resulting mesh.

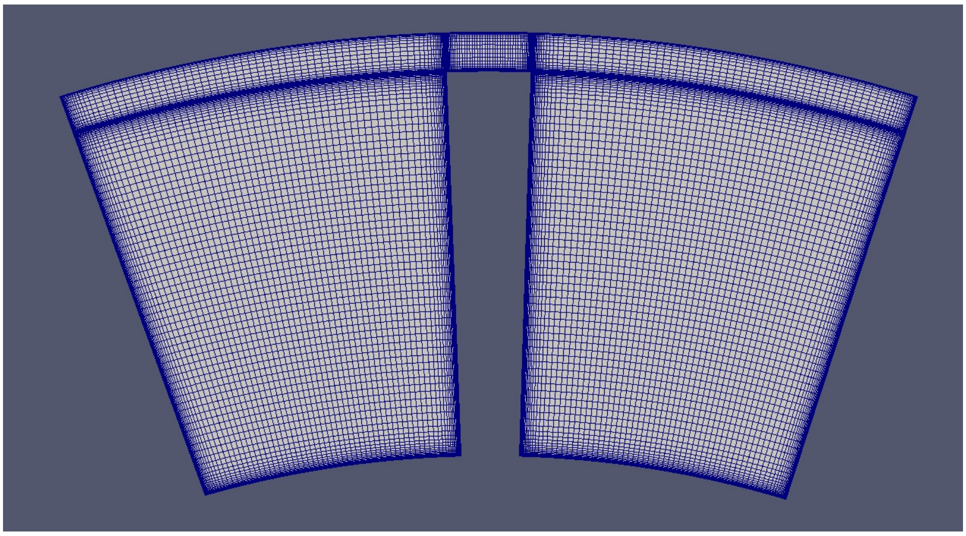

Figure 1. This is the initial mesh of a blade tip test case. In this case, a displacement is applied to the blade, in which numerical noise is included, and in the figures that follow (fig. 2) a comparison between the strict movement of the boundaries and the CAD-Free soft handle parameterization tool is demonstrated.

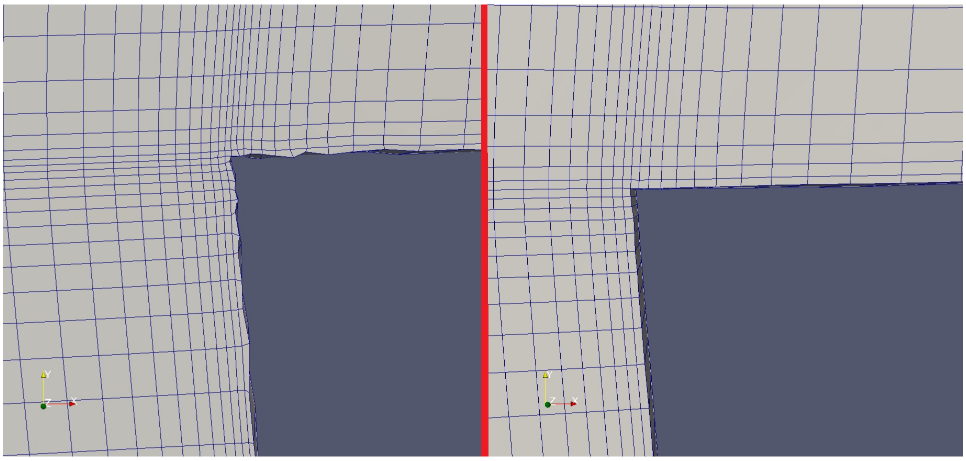

Figure 2. In this figure a comparison is made between the strict movement of the boundaries (left) and the implementation of the CAD-free soft handle parameterization tool (right). The resulting surfaces after the implementation of CAD-free soft handle parameterization do show improvement (A focus is made around the area of interest).

References

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