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Adjoint-based Volumetric Blade Optimization

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In the realm of gradient-based optimization methods used for turbomachinery design it is essential to have a fully automated design chain with a parameterization to handle complex shapes and explore large design spaces as well as calculate the design sensitivities at a low computational cost.

Therefore, we construct the geometry directly as a NURBS *volume*, where an initial template is created and its control points are repositioned explicitly by applying a series of smooth deformation volumes, allowing to control the airfoil, blend and endwall shape effectively. To set up a mesh deformation tool, an initially generated mesh is parameterized once within the volume and for every new design, the deformed mesh is created by evaluating the volume at the parameterized values. This allows to handle boundary layer cells ($y^+ \approx$ const.) as well as structured and unstructured meshes in a natural way. Finally, algorithmic differentiation in reverse mode together with performance optimizations are applied to construct and maintain a consistent and efficient adjoint solver. Implementation details and results for structured meshes have been presented in [1, 2], and we will show the validation also for unstructured meshes.

The entire new aerodynamic design chain is used to optimize the endwall of a turning vane in an inter-turbine duct. This will demonstrate the efficiency and robustness of the new approach even for large contouring deformations.

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