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TOWARDS UNSTEADY ADJOINT ANALYSIS FOR TURBOMACHINERY APPLICATIONS

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The steady adjoint method is widely used in the field of gradient based optimization for computing the derivatives of objective functions with respect to design variables [1, 2, 3]. The benefit is that the computational cost is almost independent of the number of the design variables and only dependent on the number of the objective functions, which in CFD applications are significantly less. The need for these gradients also for time-dependent problems together with the recent advances of high-performance computing naturally leads to the consideration of unsteady adjoint calculations. The unsteady adjoint method provides a clearer perception of the unsteady phenomena that occur inside a turbomachine and lays the foundation for new concepts in aerodynamic shape optimization.

In the present paper, a mathematical overview of the discrete unsteady adjoint method is presented and the final form of the equations is discussed. Within the present work, an unsteady adjoint solver has been developed and applied to turbomachinery test-cases. The solver uses a dual time-stepping scheme (physical and numerical), multigrid acceleration and the Spalart-Allmaras turbulence model with wall functions. The primal fl ow is imported for every time-step and the corresponding unsteady adjoint fl ow is calculated. Automatic Differentiation (TAPENADE) was used for selected source code differentiation.

The results and the computational cost are presented, analyzed and compared with the equivalent steady results. The dominant frequencies and the variation of adjoint fl ow variables through time are examined. In the end, the necessity for RAM and disk storage reduction techniques is discussed.

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