MESH MORPHING AND OPTIMIZATION OF TRANSONIC WINGS

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ABSTRACT

Advanced mesh morphing techniques are applied to the geometric optimization of aircraft wings and wing components. As a proof-of-concept, the potential of this new approach is exploited for the drag minimization of the main wing of the innovative three lifting surface configuration. This configuration features an anterior, all movable canard and a T tail configuration.

The classic approach to shape optimization requires the definition of geometrical parameterization of the Computer-Aided Design (CAD) model. In this case, whenever a parameter is changed, a new mesh must be generated for the new configuration. For large three-dimensional models this operation can have a very high computational cost. With the mesh morphing approach, the parameterization is defined directly on the numerical model used for calculations, which is generated only once at the beginning of the procedure and is then updated. Thus, there is no need to mesh the CAD model for each new configuration required by the optimiser, significantly simplifying and speeding-up the optimization process. In addition, this is often the only feasible approach in applications where the requirements on the quality of the final mesh make it difficult to fully automate the grid generation process.

The proposed morphing methodology is based on Moving Least Square patches technique used in surface reconstructions from scattered data. The technique has already been successfully applied to fluid-structure interface problems. The main advantages of the proposed technique are its independence from the numerical formulation of the Computational Fluid Dynamics (CFD) solver and its computational efficiency, which makes this algorithm significantly faster than other methods proposed in literature, including the state-of-art RBF morphing.

The optimization analysis will search for the minimal drag wing evaluated with the minimal drag control surface configuration and therefore movable control surface rotations will be considered during the optimization by means of the mesh morphing.

To accelerate the optimization procedure we take advantage of the efficiency of surrogate models based on response surfaces, a technique commonly adopted in CFD to replace the typical costly aerodynamics evaluations with cheaper models. To populate the initial Design of Experiments (DOE) required

to create response surface approximations, a Navier-Stokes solver has been used.

The design process and the following optimizations have been implemented using Nexus, a novel multi-disciplinary and multi-objective process integration and optimization suite. Main advantage of using Nexus in this work has been its ability to directly integrate external CFD solvers and to link mesh-morphing tools as well as to chain different optimization tasks so to mix Fast-Genetic Algorithms with Gradient Based Methods.

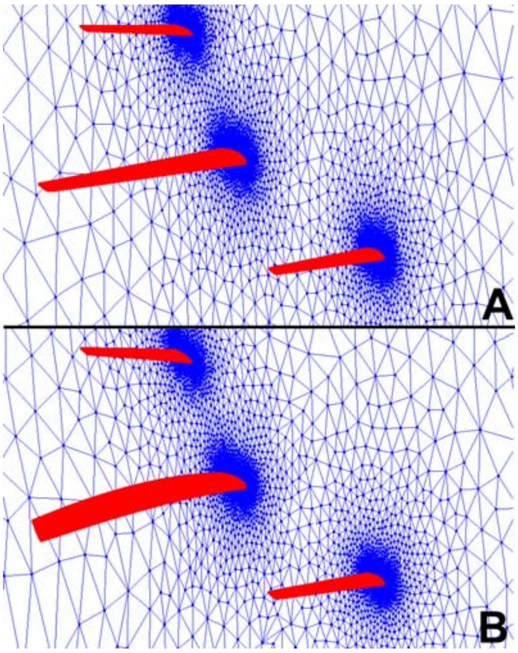

Fig. 1: MLS wing morphing: A) initial shape, B) morphed shape

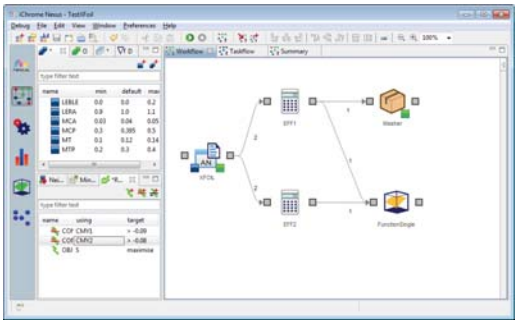

Fig. 2: Optimization Process integrated in Nexus

SUGGESTED THEMES

Mesh Morphing / Process Integration / Optimization