Adjoint and EAs based aerodynamic shape optimization on industrial test cases using RBF4AERO platform

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In this paper multiple industrial aerodynamic shape optimization problems solved through the RBF4AERO platform employing OpenFOAM® as a CFD solver are presented. The platform combines adjoint and Evolutionary Algorithms (EAs) based optimization algorithms and multi-physics analysis tools together with a mesh morphing software RBF Morph™. The morphing tool is based on radial basis functions and presents a fast and robust way of handling mesh and geometry deformations, facing two challenging tasks related to shape optimization with the same tool, avoiding re-meshing prior to each CFD simulation.

The first set of problems employed continuous adjoint method developed in the OpenFOAM® environment in order to tackle: the minimization of the cooling losses for an electric motor installed on a lightweight aircraft by controlling the cooling air intake shape; the shape optimization of a glider geometry targeting maximum lift-to-drag ratio by mainly optimizing the wing-fuselage junction. Since the first problem utilizes a porous media to simulate the pressure drop over the radiator, the adjoint to this porosity model was developed and is also presented.

The second set of problems was approached by using EAs based optimization algorithm assisted by metamodels trained on a sampling performed during the Design-of-Experiment phase. The use of Response Surface Models significantly reduced the number of OpenFOAM® CFD runs required to reach the optimal solution(s). Using this technique, the two problems already investigated with adjoint optimization were tackled; a third one, related to the minimization of drag of an underwing nacelle by controlling its shape, has been added.

Finally, a fast and efficient mesh morphing based technique to perform Fluid Structure Interaction (FSI) analyses for aeroelastic design and optimization applications is presented. The analysis is based on mode superposition method where structural vibration modes of the geometry of interest are calculated in a pre-processing stage by means of a FEM solver and later imported into the RBF Morph™ tool to create a set of individual basic deformations. Aerodynamic loads calculated with the OpenFOAM® solver are then projected onto the accounted structural modes in order to iteratively obtain the deformed configuration. The procedure was used in order to optimize the propeller efficiency of an electric airplane incorporating also FSI deformations.

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