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CFD MESH DEFORMATION CONTROL AND QUALITY ASSESSMENT FOR FSI ANALYSIS

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In coupled systems the proper behavior of the structure and the fluid is essential. In aeronautics problems the aeroelastic computations are preformed (Roszak et al.), in which the strain of the airplane structure influences the shape of the fluid domain and inversely – the pressure from CFD simulation is applied as input load for the next structural analysis. The correct representation of the fluid grid in the subsequent time steps of fluid-structure interaction computations is very important.

In (Farhat et al., 2002) it was proposed to treat the dynamic mesh as the third field of FSI investigation – together with the fluid and structural areas – with the same importance. The proper definition of this problem leads to specification of the fluid mesh internal nodes, which are formulated as the function of displacements, including the mesh quality and control. The correctly modified mesh consists of the displaced and modified elements preserving matrix connectivity. Hence, the selection of proper and fast deformation method and efficient quality metrics for modified elements is very significant.

There are many deformation methods for fluid mesh, which are used to solve the presented problem. The vast majority of them can be divided into two main groups (Kovalev et al., 2005):

- remeshing – methods for meshes with changing connectivity matrix, where the interpolation of the whole fluid domain is performed. It is conducted by mesh coarsening and/or refinement;
- methods for meshes with constant connectivity matrix, where the interpolation algorithms are applied and both the number of elements and element connectivity matrix remain constant.

Among the most common procedures used for deformation problem the most popular are: spring analogy, elastic analogy and isoparametric mapping.

The application of the quality metrics determines the modified elements during aeroelastic simulation. It is important aspect helping to estimate, whether the deformed mesh is proper or not. The primary criterion to evaluate the elements is the condition, that the whole elements should be non-inverted. The parameter defining the quality of the deformed elements is the Jacobian matrix, on which the most significant quality metrics (shape, orientation, volume) for straight-sided elements are formulated (Knupp, 2002). When dealing with curvilinear elements, the problem to define quality metrics becomes more complex. Then, the introduction of additional interpolating functions is necessary to define proper quality metrics. One of these methods is application of the Bezier functions (Remacle, 2011) in order to define the minimal bound of Jacobian. This approach helps to determine the required element quality, which enables to conduct the FSI computation.

During realization of European Projects like TAURUS or IDIHOM, the proper mesh quality assessment was crucial for correct simulations. The problem of aeroelastic computations of LANN wing with application of high-order methods is concerned in IDIHOM project. The numerical model consists of straight-line elements and the second one consists of isoparametric curvilinear elements (2^{nd} order). The information about Jacobian values as the joint quality metric of two different discretized models leads to the comparison of these models. It could be used to determine the material parameters in elastic analogy. This approach helps to define the quality metric in deformation process included in FSI simulations.

In this paper the quality control of the deformed LANN wing (consisting of straight-sided and curvilinear elements) during multiphysics simulation is presented.

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