

MESH CURVING TECHNIQUES AND PARALLEL SIMULATIONS OF HIGH ORDER DISCONTINUOUS GALERKIN SCHEMES ON UNSTRUCTURED MESHES

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KEYWORDS –

ABSTRACT –

In this talk, the application of the high order Discontinuous Galerkin scheme for computational fluid dynamics is presented. In the first part, techniques to generate high order mesh information at curved domain boundaries are discussed and in the second part, the parallel concept and strong scaling of the simulation software is shown.

Meshes with linear edges are the standard of today's state-of-the-art meshing software. Industrial applications typically imply geometrically complex domains, mostly described by curved domain boundaries. To apply high order methods in this context, the geometry - in contrast to classical low order methods - has to be represented with a high order approximation, too. Therefore, a high order element mapping has to be used for the discretization of curved domain boundaries. The main idea here is to rely on existing linear mesh generation and provide additional information to produce high order curved elements, where several techniques also involving the ANSA mesh generator are shown. A very promising candidate for future numerical solvers in computational fluid dynamics is the family of high order discontinuous Galerkin (DG) schemes. They are locally conservative schemes, with a continuous polynomial representation within each element and allow a discontinuous solution across element faces. Elements couple only to direct face neighbors, and the discontinuity is resolved via numerical flux functions. One of the reasons making high order DG schemes attractive for the simulation of fluid dynamics is their parallel efficiency. As future applications in fluid dynamics comprise the resolution of three-dimensional unsteady effects and are increasingly complex, the simulations require more and more computing resources, and weak and strong scalability of the numerical method becomes extremely important.

Therefore, the parallelization concept of the DG code FLEXI is described. A new domain decomposition strategy based on space-filling curves is introduced, and is shown to be simple and flexible. A thorough parallel performance analysis conforms that the overall implementation scales perfectly. Ideal speed-up is maintained for high polynomial degrees, up to the limit of one element per core. As the DG scheme only communicates with direct neighbors, the same parallel efficiency is found on both cartesian meshes as well as fully unstructured meshes. The findings underline that the proposed Discontinuous Galerkin scheme exhibit a great potential for highly resolved simulations on current and future large scale parallel computer systems.