Isogeometric Analysis in Industrial Turbomachinery Applications

Joint MSc-project by

MTU Aero Engines

Motivation

Isogeometric Analysis (IgA) is a recent methodology for the computational study of all types of engineering problems. It has been introduced in [Hu05] as a universal framework that aims at bridging the gap between geometry modelling in Computer-Aided Design (CAD) systems and finite element analysis (FEA) of fluid flow, structural mechanics and fluid-structure interaction problems. The essential key technology that brings the two worlds, CAD and FEA, closer together is the common use of advanced Spline technologies to model complex geometries like the Turing-Mid-Turbine-Frame (TMTF), which is a performance-critical part of most modern aircraft engines (shown left), and to represent approximate solutions to, say, a computational fluid-flow analysis (shown right).

As a major benefit, there is no more need of an irreversible approximate conversion of the accurate geometry parameterization into a discrete computational grid, which allows for much more effective shape optimization processes as they are needed in industrial turbomachinery applications.

MTU Aero Engines located in Munich, Germany, is one of the world’s leading aircraft engine manufacturers and services provides with state-of-the-art in-house development workflows. In the ongoing EU-funded MOTOR project, MTU has added novel adaptive Spline technologies into their workflow, which gives much more flexibility in designing the shape of the TMTF flow passage (shown right), which in turn enables the design of more energy-efficient aircraft engines.
Problem description and challenges

The task of this master thesis is to participate in the joint development of an IgA-solver for compressible viscous flows and advance it to a maturity level that enables its use in industrial turbomachinery applications. As a starting point, an inviscid compressible flow solver is available from the aforementioned MOTOR project, with active development taking place at TU Delft and Lodz University of Technology, Poland.

The main tasks of this master thesis are as follows:

1. Familiarization with the concept of isogeometric analysis both for geometry modelling and numerical fluid-flow analysis and acquirement of basic knowledge in gas dynamics.
2. Development of periodic boundary conditions into the IgA flow solver and performance of preliminary 3D studies of compressible flows through MTU’s demonstrator TMTF flow passage.
3. Extension of the 3D Navier-Stokes IgA-solver to a rotating frame of reference, which is required to model the flow behavior in rotating engine parts upstream and downstream the static TMTF.
4. Coupling of the static Navier-Stokes IgA-solver with its rotating counterpart and performance of preliminary 3D studies of compressible flows through MTU’s demonstrator TMTF flow passage.

Possible additional task:

5. The utilized software library G+Smo [GS] provides state-of-the-art technologies for generating locally refined B-splines bases, so-called truncated hierarchical B-Splines (THB-Splines) [Gi12]. Upon successful completion of the aforementioned main tasks, the use of THB-Splines can be exploited to improve the geometry and solution representation by refining the Spline space locally.

The main challenges of this ambitious master project consist in the bleeding-edge nature of the utilized technologies being under active development and the necessary maturity level of the IgA-solver that is required for being able to solve challenging industrial turbomachinery applications of this type.

Time schedule

The project is carried out in strong collaboration with MTU Aero Engines, Germany. The student is expected to stay part of the project time (ranging from 2 weeks to 3 months) at MTU in Munich.

Contact

For more information about this MSc-project contact Dr. Matthias Möller (M.Moller@tudelft.nl) or Dr. David Grossmann (David.GROSSMANN@mtu.de).

Literature

