Semesterarbeit / Master Thesis

Institute of Helicopter Technology

CFD-based unsteady aerodynamic reduced-order model (ROM) for rotorcraft application

Background:

The unsteady motion of aerodynamic surfaces, such as blades on rotors in edgewise flight and wings on aircraft during turbulence, can significantly influence the aerodynamic loads. These loads cannot be represented accurately using steady or quasi-steady airfoil aerodynamic performance methods. Therefore, unsteady aerodynamic theories exist to model aerodynamics in such regimes. Classical unsteady models (e.g. those by Theodorsen and Wagner) are based on potential flow theory. Despite the limitations of potential flow analysis, these derivative models have found prolific use in unsteady fixed-wing analyses (for e.g. flutter) as well as rotary-wing applications. This can be attributed to the mathematical derivation resulting in physically intuitive quantities that lead to aerodynamic loads. Naturally, potential flow theory based models cannot predict drag (since flow viscosity is ignored). A common approach in rotorcraft analysis codes is to use a form of the aforementioned unsteady models for lift and moment prediction and use an empirical correction to obtain unsteady drag. This stop-gap solution, needs to be tweaked (only the drag analysis part) based on the problem being investigated.

Goal:

To remedy this situation, the proposed problem statement seeks to obtain an improvement to these existing unsteady models using URANS-based 2D airfoil aerodynamics results (Cl, Cd, and Cm) to modify quantities within the potential flow theory-based models. A URANS-based 2D CFD analysis framework (using TAU solver) already exists and will be made available to the student. The proposed task involves familiarising with that framework and generating aerodynamic results for a parametric sweep of independent airfoil modes (for e.g. pitching, plunging, trailing-edge deflection) at various frequencies. Knowledge of frequency domain airfoil aerodynamic performance can then be used in conjunction with the Theodorsen's model to incorporate the effect of finite thickness of airfoil sections, viscous drag etc. This frequency domain model can finally be transformed to time domain and be incorporated into a larger rotorcraft flight mechanics code to accurately quantify higher-fidelity unsteady aerodynamic effects. The main aim would be to obtain unsteady ROM for an airfoil with trailing-edge flap and an airfoil with active camber morphing ability, and compare and contrast the results.

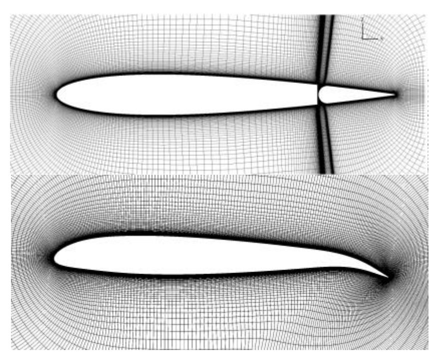
Skills:

Good understanding of fluid mechanics and CFD methods.

Tools: Python

Language: English

Start: As soon as possible



Contact:

Sumeet Kumar, Jonas John
Institute of Helicopter Technology
Email: sumeet.kumar@tum.de/
jonas.john@tum.de
Tel: +49 (0)89 / 289-16307
+49 (0)89 / 289-16563