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Corresponding author: Hemant Joshi
e-mail of corresponding author: h.joshi2@herts.ac.uk

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Title
Fast frequency based unsteady solver for heaving and pitching subsonic and supersonic airfoils.

Authors

Hemant Joshi [1], Peter Thomas [2]*

** Corresponding author*
[1] UNIVERSITY OF HERTFORDSHIRE ▪Hatfield, Hertfordshire, AL109AB, United Kingdom, h.joshi2@herts.ac.uk
[2] UNIVERSITY OF HERTFORDSHIRE ▪Hatfield, Hertfordshire, AL109AB, United Kingdom, p.thomas5@herts.ac.uk

Abstract

This report proposed a computational build of unsteady vortex lattice method for fast airfoil analysis at both subsonic and supersonic conditions. This research is proposed as an extension to TORNADO's framework providing a low order unsteady solver for analysis, multiphase optimization and aeroelasticity.

This framework is based on the Theordorsen's approach of frequency-based analysis which effectively reduced the cost associated with high order CFD solvers. This unsteady solver computes the induced flow to calculate the forces acting on the panel with respect to time. Improvements have been done to increase its efficiency to work under supersonic conditions and solve it for higher frequency motions. The validation of the code is done with CFD and available literature. Since cost is one of the major reasons for design problems in the next generation of aircraft designs, this solver holds good potential for implementation in early design optimisation work. For the improvement of the solver in supersonic conditions following measures have been proposed.

- New improved influence function will be emphasised on the local loading point of a lattice and its influence for supersonic speeds considering the horseshoe vortices distribution over wing elements with small chords and spans.
- The region of integration stretches on the wing planform inside the Mach fore cone originating from the field point. Improving on the elementary vortex distribution for supersonic flow.
- Use of Taylor McColl is proposed for improved drag prediction and velocity change from transition of subsonic to supersonic speeds over an airfoil.
- A new section of LBM is explored for predicting the compressibility correction around a supersonic flow regime.
- Modeling the bound vortices and shed vortices over the leading edge of an airfoil which will improve the overall accuracy in predicting the flow of an entire airfoil.

The UVLM code predicts two dynamic motions experienced by an airfoil: heaving and pitching motion. The set of motions are user defined and can alter with respect to flow speed, angle of attack and density of air. The code relies on two stages, the first to carry out the solver process from the initialising parameters obtained from the TORNADO's environment. The second is visualizing and storing the data This model considers the aerodynamics capabilities of low order method and its use for preliminary design stage, the model has been developed as my PhD work, and it has been validated against literature in order to check its deviation from high order CFD published work. This work is a section of the development of low cost, fast analysis solver for preliminary design stage which have a potential to be used for the multi-phase design optimization of next generation of airfoils and aircrafts.