Semesterarbeit / Master Thesis

Institute of Helicopter Technology

Ground-effect modelling using viscous vortex particle method

Background:

Currently, there is an incredible push towards cleaner modes of transport and electric vertical take-off and landing aircraft (eVTOLs) have garnered much interest as a consequence. The excitement is especially justified because rotor configurations that proved practically unviable using turboshaft/piston engines are now completely realizable opening up a Pandora's box of possibilities with regard to rotorcraft designs. One particular notion is that of distributed propulsion whereby the aircraft has a number of propellers/rotors placed all over the aircraft. This makes the modelling and simulation phase especially critical that the chosen design from a large number of possibilities is the most optimal given the objectives – a given range with minimum fuel, limitation on noise etc. – is achieved. A lot of the existing tools from conventional helicopter analyses can be directly adopted for eVTOL design and optimization for this pupose. However, existing rotor wake modelling techniques falter when it comes to modelling contra-rotating rotors or modelling close rotor-wing interactions accurately. Viscous vortex particle method (VVPM) is particularly suited to model such configurations since traditional free-wake methods, the workhorse of conventional rotor wake analyses, have proven to be unstable in case of mixing flows.

An in-house VVPM code (C++) exists, along with any relevant visualization and plotting routines, that has been verified both standalone as well as coupled to a rotor dynamics solver to model rotors with elastic deformation. The current VVPM implementation is based on unbounded flows so that the influence of buildings adjacent to the rotor or the ground beneath the rotor, in case of hover flight close to the ground, cannot be modelled. Bounded scenarios are of interest because eVTOLs are envisaged as a modern means of transport within city limits where operation of these multicopters in close proximity to building rooftops can dramatically influence the rotor aerodynamics and controllability of the design.

Goal:

The proposed work would involve incorporating capability within VVPM to model effect of 'blocking' surfaces. The validity of the implementation would be verified using an existing rotary-winged flight case.

Skills:

A basic understanding of rotor aerodynamics required.

Tools: C++ and Python programming

Language: English

Start: As soon as possible

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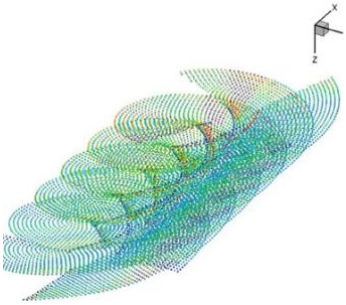
Various eVTOL designs

Single rotor in ground-effect



Single rotor wake modelled using (unbounded) VVPM