Numerical Modelling of Sailing Hydrofoil Boats

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Motivation

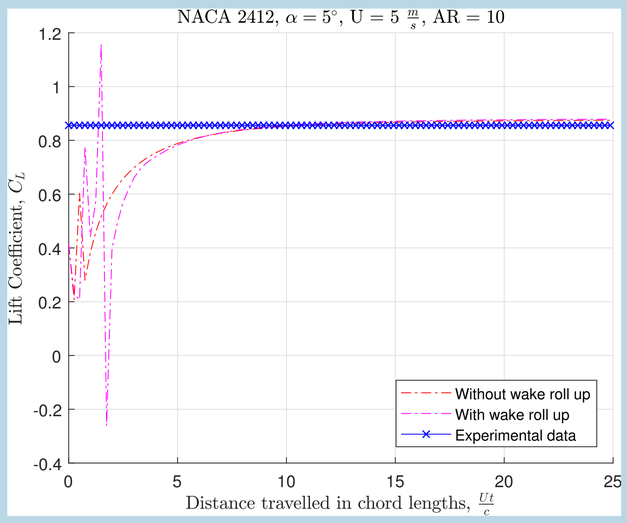
The motivation of this thesis stems from the desire to create a training simulator for experienced sailors not familiar with sailing hydrofoils. As such the current task is to view the feasibility of using a potential flow approach to numerical assessment of sailing hydrofoil vessels. As the task at hand is to large for one person, the task has been limited to only foil-borne conditions.

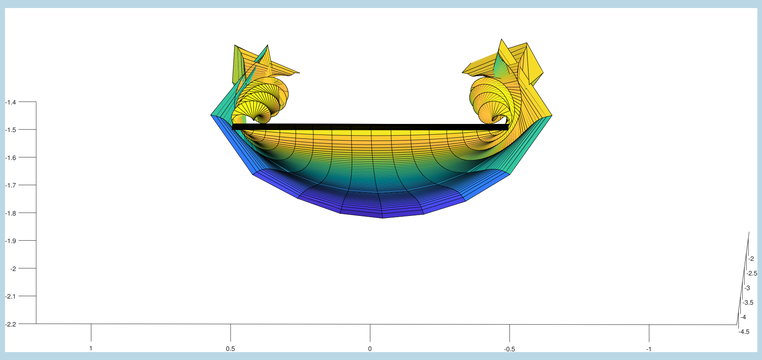
Underlying Model

An unsteady vortex lattice method is a potential flow boundary element method meant for lifting problems. Briefly explained the UVLM model solves Laplace's equation within the parameters of linear foil theory. It accomplishes this by applying boundary conditions directly onto the camber line of the foil thus disregarding the effect of thickness and solving the condition with a distribution of vortex singularities. Where the condition to be solved is zero normal flow across the surface.

Wake

The wake roll up was found to have a negligible effect on the lift. The initial unstable behaviour of lift is contributed to faulty initial conditions. A work around was implemented by allowing the wake to be formed before the simulation started.





References

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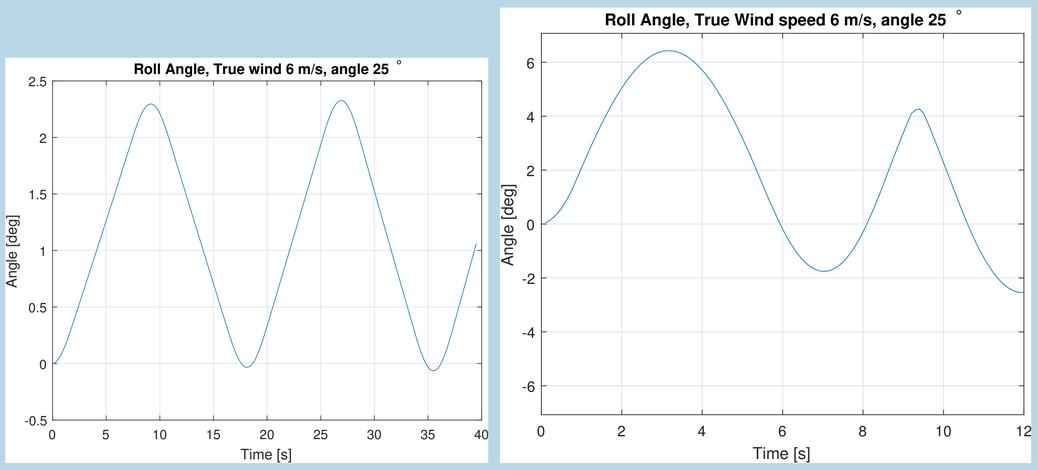
Dynamical Vessel Simulation

The current model is able to model upwind sailing conditions, downwind sailing condition are not feasible due to the assumptions within potential flow. The main reason not being accurate for large angles of attack. Both 1 DOF simulations and 4 DOF simulations were performed. 1 DOF simulations were performed to test whether the vessel would eventually restore itself, below is a 1 DOF simulation for roll motion. 4 DOF simulation were performed to test the dynamic behaviour, where roll motion against is shown below for a single wind angle and wind angles between 25 and 75. The neglections in 4 DOF simulations were sway and yaw due to programming complications and based on (Masuyama,1987) the sideslip angle is small.



Validation and Verification of the UVLM

Based on the investigations carried out it is believed the created lifting surface model sufficiently models the effects of camber and aspect ratio during attached conditions. Furthermore, the modelling of dynamic lift is also believed to be sufficiently accurate during attached conditions, which was validated against Theodorsen's function.