A Strip Theory Approximation for Wave Forces on Submerged Vehicles in Finite Depth Water

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Abstract

Autonomous Underwater Vehicles (AUV's) are becoming of increasing use in shallow waters for oceanographic data collection, coastal mapping, and military operations such as mine surveillance along enemy coastlines. Currently the control of AUV's in shallow water is very limited, largely due to a lack of knowledge of vessel forces in shallow water, especially in the presence of surface wave effects. The limitations of current control systems do not afford enough confidence to operate the vehicles in very close proximity to shore or in large waves because the control in the horizontal plane is not adequately reliable enough to prevent bottoming and free surface broaching.

Current control system parameters are altered through trial and error to enable reasonable vehicle behavior in shallow water but the control of the vehicle is limited because a thorough understanding of wave forces on these vehicles is non existent. The development of a good analytical tool which adequately models wave forces and moments on an AUV in shallow water waves will enable the development of control systems which will be better able to maneuver the vehicle in shallower water and larger waves than the conditions in which AUV's are currently used.

The purpose of this thesis is to further develop, verify, and apply a Strip Theory based analytical tool, which has been developed by Prof. Jerry Milgram. The developed code models dynamic wave forces on a small submarine in shallow submergence and finite depth water through the use of a Strip Theory summation of cross section forces calculated through Green's theorem in a two dimensional panel method code. For this thesis a study of three dimensional flow effects on the control fins is conducted through the use of WAMIT, a three-dimensional panel method code for marine structures. The code is tested for data convergence to determine the sizing of both the Greens theorem solution domain and the panel sizing for the solution. To validate the accuracy and reliability of the Strip Theory Code in question, its results are compared to WAMIT output for identical test conditions. Also, existing experimental data for the REMUS AUV is used as a comparison and validation for the code. The resulting code correctly models sway, heave, pitch, and yaw forces and moments with reasonable accuracy and it can be used in future work to develop more reliable control systems and operating limitations for AUV's.

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