Experimental Verification of Biomimetically Designed Ventral Fins for AUVs

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Abstract

Biomimetics, nature inspiring technology, is the concept of imitating nature models for the purpose of solving complex problems [1]. Finding the right analogs from biology to technology, transferring, and applying them correctly can potentially make a big difference in improving a system.

In this thesis, we investigated and verified the impact of different dorsal fins sizes on the REMUS 100 AUV's ability to maneuver. Observing the past work of Triantafyllou [2] and Ross [3] that suggested better maneuverability capabilities, continued by Prestero [4] and Trakht [5] that provided theoretical and simulation tools for better understanding the impact of fins on maneuverability, and Winey's work [6] that produced empirical data to support Triantafyllou's theoretical work, we will now follow the conclusions of previous works and provide the appropriate conditions to meet the requirements for better maneuverability.

The towing tank at MIT Sea Grant is equipped with four motors, allowing the model to have 3 degrees of freedom: longitudinal direction (x), transverse (y), and radial motion around the vertical direction (z). Using this equipment, we made yaw and sway experiments of a modified scaled-down model based on the REMUS 100 (Remote Environmental Monitoring Unit), which was developed by C. von Alt and associates at the Oceanographic System Laboratory at the Woods Hole Oceanographic Institution [7].

In this work, we reduced the area of the front fin and rudder in order to be close to the instability point. Using the towing tank to generate oscillating sinusoidal motion to the REMUS model, we made a series of experiments in combinations of different fin locations, frequencies, and fin sizes. We compared the results to the original model as described by Triantafyllou et al. [6], as to theoretical calculations performed by Triantafyllou [8], and Hoerner [9],[10]. Scaling up the results using a similitude method, we could simulate the maneuverability characteristics of the REMUS 100 AUV.

We quantified and verified that minimizing the stability criterion indeed provide better maneuvering performance in terms of the radius of turning, turning rate, surge velocity, and drift angle. Providing a method of optimizing an existing model, we showed ways to minimize the stability criterion to a specific required value, while verifying the conditions needed to do so.

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