Data-driven Locomotive Strategies of the UVMS Propelled by Undulating Fins

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ABSTRACT

This paper addresses a data-driven locomotive strategy of an underwater vehicle-manipulator system (UVMS). Two modular designed biomimetic underwater propellers are deployed on the UVMS. Each propeller has a ribbon fin that consists of twelve rays linked by a thin latex membrane. Each ray is individually actuated. By distributing all rays in phases of undulating patterns, different form of waves can be generated from the propeller. A measurement platform is constructed to obtain the horizontal and vertical force generated by the waves of the undulating fin. The current in main circuit of the propeller is also measured. The measured data are calculated into five output results. Three types of waves are performed on the platform, including sinusoidal waves, fusiform sinusoidal waves and inward counter-propagating sinusoidal waves. Output results are varied by parameters of undulating patterns. By diversifying parameters of undulating patterns, multiple waves are carried out and their output results are obtained. With these data, a locomotive strategy for the UVMS is established. The strategy is to select the output results of the two propellers by optimization methods to meet the requirements of the UVMS on standards of driving force, stability and power consumption. With this strategy, two biomimetic propellers can perform suitable undulating patterns when the UVMS is required to implement certain locomotions.

KEY WORDS: Biomimetics; Undulating fin; UVMS.

INTRODUCTION

Biomimetic underwater vehicles (BUVs) propelled by undulating fins have gained much attention in recent years. When propelled by undulating fins, BUVs receive remarkable maneuverability and can perform small range movement and stably hover at a low speed (Sefati et al., 2012). Many universities and institutions have designed and built BUVs with undulating fins for research. In Northwestern University, a robotic ribbon fin (Epstein et al., 2006) and later a biomimetic knifefish robot (Curet et al., 2010) were built. Experiments with the robots on testbed (Epstein et al., 2006; Sefati et al., 2012; Neveln et al., 2014), numerical simulations by computational fluid dynamics (CFD) (Bale et al., 2014; Neveln et al., 2014) and flow visualization by digital particle image velocimetry (DPIV) (Shirgaonkar et al., 2008; Curet et al., 2010)