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Volumetric PIV of multiple free-swimming maneuvers generated by the KnifeBot: a biomimetic vessel propelled by an undulating fin.[1]
HANLIN LIU, Florida Atlantic University, DANIEL TROOLIN, RUBEN HORTENSIUS, STAMATIOS POTHOS, TSI, OSCAR CURET, Florida Atlantic University — An undulating fin represents a remarkable propulsion model for underwater vehicles due to its high propulsive efficiency and considerable locomotor capabilities. In this work, we used a bio-inspired vessel, the KnifeBot to demonstrate the maneuverability of undulating fin propulsion, including forward-backward swimming, station keeping and vertical swimming. This self-contained robotic system uses an undulating ventral fin as the propulsor and features a slender 3D-printed hull with 16 motors, 2 batteries and electronic boards encapsulated inside. We tested the robot in a water-filled tank and used volumetric particle image velocimetry (V3V PIV) to investigate the three-dimensional flow features and vortex structures generated by the undulating ribbon fin in free-swimming maneuvers. Our results indicate that in the forward swimming, a series of vortex tubes are shed off the fin edge. A streamwise jet at an oblique angle to the fin is generated in association with the vortex tubes propelling the robot forward as well as pitching it up. For the hovering maneuver with inward counter-propagating waves. The streamlines develop vertically downward with the tip vortex shed from the fin edge. This downward jet provides substantial heave force for the robot to swim upward or perform station keeping. Our findings will be useful for understanding the mechanical basis of undulating fin propulsion and facilitate the development of bio-inspired vehicles using undulatory propellers.

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