Propulsion optimization of a jellyfish-inspired robot based on non-intrusive reduced-order model with proper orthogonal decomposition

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Abstract

A novel design of a jellyfish-inspired mantle undulated propulsion robot is presented, aiming at a swimmer with good orientation and high propulsion efficiency. An effective reduced-order model is proposed to establish the mapping between the parameter-driven motion of the mantle and the evolution of the fluid characteristics around the swimmer. Moreover, to predict new cases where the input needs to be updated, the input of the proposed model is taken in the form of a sinusoidal signal extracted from the kinematics of the robot rather than extracted from full-order systems. The results show that compared with other models, the proposed method can efficiently update the input, providing reasonable predictions for new cases. The analysis of the hydrodynamic performance of the proposed robot pinpoints that, under a certain period and a certain tail beat amplitude, the hydrodynamic force generated by swinging-like mantle motion ($k<0.5$) is greater, but it is accompanied by considerable power loss. It is demonstrated that considering a certain power loss and a certain tail beat amplitude, the wave-like mantle motion ($k>0.5$) can produce greater propulsion, which means higher propulsion efficiency.

Keywords: jellyfish-inspired robots; motion parameter optimization; reduced-order modeling; proper orthogonal decomposition; bionic propulsion; neural networks.

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