

Optimized design and propulsion performance of the robotic sea lion foreflipper

Abstract: Otariidae are the only marine mammals that use their foreflippers for propulsion, and the combination of hydrofoil and paddle propulsion makes them excellent hunters and swimmers. Therefore, it is of great scientific significance and engineering value to develop a novel underwater propulsion technology inspired by the propulsion mode of Otariidae foreflippers. At present, the research on the Otariidae foreflipper-inspired propulsion is still in the initial stage and needs to be explored further in terms of both theory and technology. The bionic underwater robot team led by Prof. Liu of Tianjin University have made some achievements in this regard. Taking California sea lion as the bionic prototype, they developed the first generation biomimetic robotic sea lion foreflipper propulsion mechanism (Rob-flipper-I for short). In the present work, the Rob-flipper-II is developed through the optimization of the Rob-flipper-I, which is composed of a driving mechanism and a pair of bionic foreflippers. The driving mechanism consists of a wobbling disk mechanism and a spatial linkage mechanism that are connected in series, and the bionic foreflippers have similar flexibility and mechanical properties to those of the sea lion foreflippers. The Rob-flipper-II can reproduce the spatial trajectory and attitude of the sea lion foreflippers by a single drive only. Based on the kinematics analysis of the Rob-flipper-II, the formulas for calculating the thrust and lift of the bionic foreflipper are derived, and the functional relationship between the motion speed of the bionic sea lion robot and the flapping frequency of the bionic foreflippers are obtained. In addition, the propulsive efficiency of the Rob-flipper-II is calculated. The tank experiment shows that the average thrust and propulsive efficiency of the Rob-flipper-II are higher than those of the Rob-flipper-I.

Keywords: Bionic Propulsion; Sea Lion Foreflipper; Propulsion Mechanism; Bionic Flexible Foreflipper; Propulsion Efficiency