Larval Zebrafish-like Efficient Undulatory Swimming

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Various robotic platforms have been proposed to study the energy efficiencies of undulatory swimmers [1]. These studies suggested the importance of non-uniform body bending stiffness distribution (*k*) in improving the efficiency of adult fish–like robots in the inertial flow regime. However, whether such an elastic mechanism is beneficial in the moderate flow regime remains unclear [2]. We develop a class of untethered soft milliswimmers consisting of a magnetic composite head and a passive elastic body with different *k*. These wireless robots achieve comparable larval zebrafish–like undulatory swimming at the same length and time scale. Investigations reveal that the combination of uniform *k* and high swimming frequency (60 to 100 Hz) is better for improving efficiency. A shape memory polymer–based milliswimmer with tunable *k* on the fly verifies the conclusion. The study guides the design of energy-efficient leading edge-driven soft undulatory milliswimmers for future environmental and biomedical applications [3].

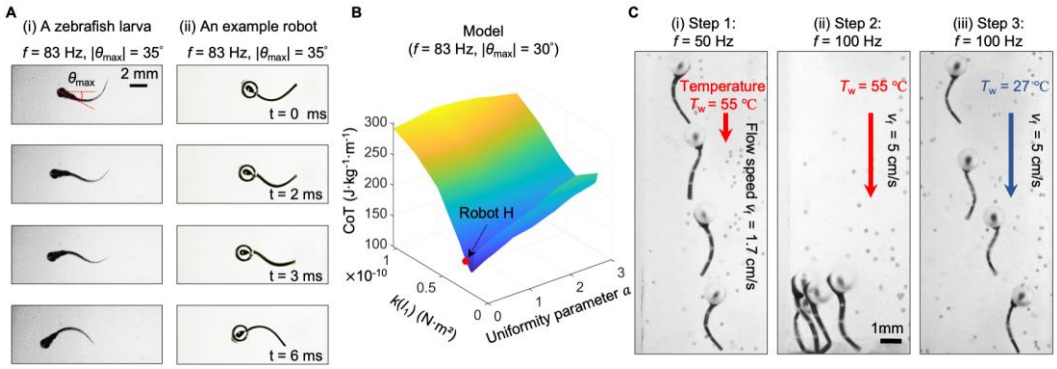

Fig. 1: Midline kinematics of a zebrafish larva and the millirobot (A), Effects of body stiffness distribution on the cost of transport (CoT) (B), and Propulsion performances of an SMP-integrated robot with the ability of on-the-fly stiffness adjustment (C).

References

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