Research on intermittent swimming based on deep reinforcement learning

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Abstract

This research explores the efficient swimming to save energy. A deep reinforcement learning (DRL) framework has been established and a robotic fish is used for testing. Our work reveals that common continuous swimming gaits are not the most energy efficient option for robotic fish. Instead, “smart swimmer” utilizes intermittent swimming gaits to enhance efficiency, which amounts to the natural “burst and coast” behavior observed in real fish. During the burst phase, the robotic fish utilizes high frequency undulations to accelerate, followed by a coast phase where it remains stationary, analogous to surfing. The key difference in intermittent swimming at different speeds is the coast phase duration. Furthermore, our computational fluid dynamics (CFD) analysis explains the energy-saving mechanism behind this intermittent swimming gait for robotic fish. Experimental results confirm the superiority of the intermittent swimming gait learned from DRL over the commonly used continuous swimming gait in robotic fish applications, reducing energy cost by 24.2%.

Keywords: deep reinforcement learning (DRL), computational fluid dynamics, robotic fish, burst and coast