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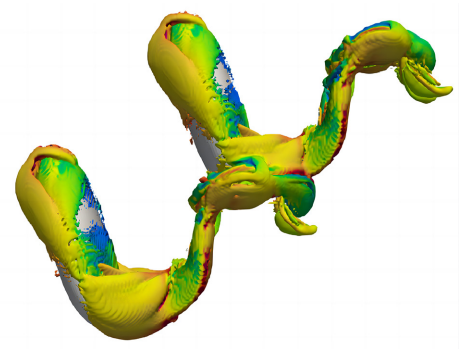
Downstream delays drive dynamic rotational velocity for group followers



For birds and fish, traveling in flocks and schools can help defend against predators and conserve individual energy reserves. Compared to solitary fish, for example, those that swim in schools — especially those in the back — are known to benefit from hydrodynamic advantages that support their “cruising” efficiency. They use less oxygen and swing their tails less frequently.

Yet, not much is known about the dynamics during “fast-starts” or emergency swimming, when a school of fish suddenly deforms and changes direction, thereby creating more complex and energetic jets and vortices.

Song et al. employed 3D computational fluid dynamics (CFD) simulations to investigate the hydrodynamic effects between a pair of fish with identical geometry and movement patterns during fast-start.

“Our research aims to uncover how fish benefit from their neighbors in terms of escape distance and rotational angle,” said author Jialei Song. “Our findings indicate that by utilizing the wake generated by neighboring fish, an individual can enhance both its escape distance and angle.”

Using a model derived from an adult carp, the researchers conducted 100 CFD simulations in high-performance computing clusters to observe various aspects of translational and rotational movement.

“Intriguingly, if a downstream fish delays its reaction for a certain period, it can achieve a higher rotational velocity,” said Song. “This discovery aligns with the philosophical insight of the Navy Seals’ saying, ‘Slow is smooth, and smooth is fast.’”

The study may offer more than new insights into fish behavior.

“It has implications for the collective movement control of autonomous underwater vehicles in the future,” said Song.

Source: “Delayed action leads to faster turning of fish by interaction with neighbor,” by Jialei Song, Yuhan Li, Yang Xiao, Chao Wang, Yong Zhong, and Ling Yin, Physics of Fluids (2024). The article can be accessed at http://doi.org/10.1063/5.0185507.