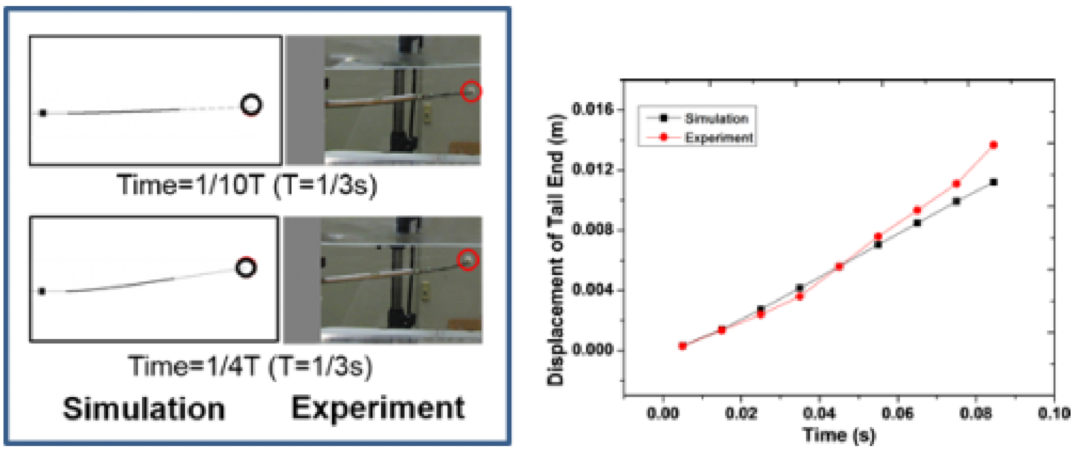
Analyzing the propulsion of a soft robotic fish

December 24 2014



Comparison between simulated and experimental displacement of the fin of a robotic fish. A successful simulation of the dynamical interaction between a soft robotic fish and its surroundings was demonstrated by researchers of the University of Electro-Communications, Tokyo. A better understanding of fish propulsion could improve the performances of fishlike robots, useful for underwater tasks.

In the world of underwater robotics, fish-like structures are able to accelerate and maneuver better than most other artificial underwater vehicles. For these reasons, fish-like robots are well suited for submarine exploration tasks. However, a complete understanding of mechanisms governing the swimming movements of fish-like robots remains elusive, limiting the performance of such underwater robot.

Notably, propulsion by undulation entails complicated interplay between body deformation and fluid motion. Developing high performance robots by utilizing such complex dynamics is the main goal of the research on robotic fish led by Aiguo Ming and colleagues at the University of Electro-Communications, Tokyo.

Recently, Ming and his colleagues including Wenjing Zhao demonstrated how fluid-structure interaction analysis can be applied to capture the propulsion of a soft robotic fish. The coupled equations describing the interaction between the fluid pressure on the robot and the load generated by the fish motion were solved numerically through a mesh method followed by a algorithm. The simulated dynamics was compared to the experimentally measured behavior of a robotic fish propelled by a piezoelectric fiber composite.

In the oscillation motion of the robotic fish, an increase in oscillation frequency led to a decrease in the displacement of tail fin, and the propulsive force has no direct proportional relationship with the robot oscillation frequency. Trends in the variation of the displacement and propulsive force of the robotic fish at different frequencies were determined by fluid-structure interaction analysis and confirmed experimentally using an actual prototype robot. The effectiveness of the fluid-structure interaction analysis was verified and was useful for evaluating the robotic fish's propulsion characteristics for improving robot design and control.

The successful analysis paves the way for future applications of fluid-structure interaction analysis to improve the performance of underwater robots.

More information: Zhao, W., Ming, A., Shimojo, M., Inoue, Y. & Maekawa, H. "Fluid-structure interaction analysis of a soft robotic fish using piezoelectric fiber composite." *Journal of Robotics and*

Mechatronics 26(5), 638-648 (2014)