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INFORMATION OF THE DISSERTATION

Dissertation's title: Dynamic Analysis and Motion Control of a Fish Robot Driven by Pectoral Fins.

Major: Mechanical Engineering

Major code: 62520103

PhD candidate: Pham Van Anh

Science advisors: **1.** Assoc. Prof. Vo Tương Quan, PhD

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Objective of dissertation

This dissertation explores the influence of pectoral fin structures at different swimming modes on a robotic fish's locomotion behavior. Some objectives are addressed to achieve the mentioned aim as follows: Firstly, new designs based on bio-inspired pectoral fin types are constructed. Secondly, to predict fin deformation and body part movement, novel dynamically mathematical models are developed. Thirdly, experimental data is also collected and measured to complete the evaluation model, including unknown coefficients and relationships between parameters. Finally, the author compares between simulation and practical responses to examine the precision of prediction models.

Contribution of dissertation

Natural fish is the master of outstandingly swimming skills. Inspired by the morphology of pectoral fin types, maneuverability, swimming speed, and energy usage efficiency of live counterpart, this dissertation presents novel findings to the fish-like robot employing the pectoral fins. Contributions are shown in some aspects as follows:

Firstly, the modeling approach for the fish robot using uniform fin was considered. Where Euler-Bernoulli beam theory, which was combined with the Morison formula, Rayleigh-Ritz method, is key to describe the deflection of pectoral in the fluid. In particular, the control law, which is quite simple, to track the variation of direction and swimming speed was also suggested. The outcomes claimed the reasonability through simulations.

Secondly, inspired by the non-uniform shape of natural fish's pectoral fins, the robot's designs employing pectoral fins as mainly propulsive actuators and their mathematical model were recommended. The analyses of the body motion and fin deformation based on the Rayleigh-Ritz method, Lagrange approach, and Morison formula, were expressed distinctly. The prediction model enabled to represent the real behavior of the robot relatively fully.

Thirdly, the novel type of pectoral fins was proposed, which significantly boosted the ratio between the thrust force and drag force, swimming speed, and maneuverability at a low range of frequencies. The robot's kinematic performance is close to its biological counterpart. The structure of the fin was inspired by the flexible motion and fundamental shape of natural fish.

Finally, as a notable contribution, the analytical model for robotic fish equipped folding fins was recommended. Proposals proved that it could broadly predict locomotion behaviors of the real prototype. This model can be directly used in the designs of motion controllers or to verify the control algorithm.

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