作品資料 Information about Project

作品名稱 Name of Project:

Underactuated Wire-Driven Mechanism and Highly Efficient Robot Fish

作品的設計目的 Objectives of Project:

Among existing robot fishes, the common propeller design is using several rigid links. Each link is controlled by one actuator. The drawbacks are: i) the structure as well as the control of the robot fish is complicated; ii) the robot fish could not mimic fish swimming curve well; iii) the propulsion efficiency is low; iv) the fish tail movement is planar. In this project, we are going to develop a type of robot fish with simpler structure, but better resembling fish movement, and with improved propulsion efficiency. The approach is the bio-inspired wire-driven mechanism.

作品的創新之處 Innovativeness of Project:

This is a novel robot fish design approach. The novelties include:
1. The wire-driven mechanism mimics the musculoskeletal system. The structure is flexible, and the motion is controlled by several pairs of wires. The flexible structure enables the robot better resembling fish swimming, while the underactuation reduces the number of actuators to the minimum. For oscillatory flapping only one motor is used; for undulatory motion, two motors are enough. This design improves the propulsion efficiency and agility of the robot.
2. Developed a novel vector propelled robot fish using this approach. It could flap its tail in arbitrary direction, providing vectored thrust. It could mimic shark swimming or dolphin swimming simultaneously. No other robot fish around the world has such ability. This improves robot's maneuverability in 3D space.
3. Developed a robot fish with twisted tail using this approach. It could replicate the twisting phenomenon in fish swimming. This is also new in robot fish development. It provides a platform for study the 3D vortex shedding of fish swimming.

作品的商業價值 Commercial Value:

There are many potential applications. For the robot fish, it could be used in surveillance, water quality monitoring, underwater exploration, water transportation, etc. For the wire-driven mechanism, it could be further applied to other robots, such as minimally invasive surgery robots, nuclear reactor inspection robots, entertainment robots, etc.

作品簡介 – 例如：動機、研究方法、發現結果及重要性、後續發展…等等 (以600字為限)
Description of Project - e.g.: Motivation, Methodology, Findings & Impacts, Future Development, etc. (Maximum 600 words):

In this project, we designed the wire-driven mechanism and built several novel robot fishes using this mechanism. The wire-driven mechanism is inspired by nature. It is an underactuated flexible system. The backbone structure is snakelike, while the actuation is done by several pairs of wires. Using this mechanism, we designed and built several novel robot fishes: 1) Wire-Driven Serpentine Oscillatory Robot Fish; 2) Wire-Driven Continuum Oscillatory Robot Fish; 3) Wire-Driven Serpentine Undulatory Robot Fish; 4) Wire-Driven Vector Propelled Robot Fish; and 5) Wire-Driven Robot Fish with Twisting Tail.

Propulsion model of these robot fishes are derived by integrating Lighthill's Elongated Body Theory and the kinematic model of the propellers. These models are all validated by swimming experiments. The robot fishes are composed by the fish body and the wire-driven tail. The streamlined body is airtight. It encloses the actuators, control board, power supply, etc. The wire-driven tail design is different from existing counterparts. It could better resemble the fish swimming body curve. Also the number of actuator used is reduced to the minimum. For oscillatory robot fishes, only one actuator is used. The cruise speed could reach 0.413 body length (BL)/ second. Also, it could turn 360°in 13 seconds, with the turning radius 0.24BL. The Froude efficiency is 62.4%, which is better than most existing robot fishes. For the undulatory robot fish, two motors are used. The two pairs of wires are parallel and in the same plane. By controlling the wire motion, the robot could swim oscillatory or undulatory. The tail motions of these three robots are all in the horizontal plane. The vector propelled robot fish has two orthogonally displaced wire pairs. Each pair of wire is connected to a servo motor. It could flap its tail both horizontally and vertically, mimicking shark swimming and dolphin swimming simultaneously. Moreover, the tail could adjust the flapping direction, providing vectored thrust. This enables the robot fish turning in arbitrary direction in 3D space effortlessly. To the best of our knowledge, there is no other robot fish with such ability. The robot fish with twisting tail also has two pairs of wires. Each pair of wire is in a plane parallel to the horizontal plane. By controlling the motion of each pair of wires, the tail could flap oscillatory with or without twisting. With this wire configuration, the robot fish could mimic the twisting phenomenon in fish swimming. This is also new in robot fish development. With the twisting, the vortex shedding is altered. This could improve the 3D motion ability of the robot. The following figure shows one of the robot fish designs.

Compared with existing robot fishes, our wire-driven robot fishes are simple in structure and control. Moreover, it better resembles the fish swimming body curve and hence, has improved efficiency and maneuverability. It will find many applications in the future.

(472 words)

其他資料 - 例如：參考文獻、照片、圖表 (不超過3頁)
Other Information of Project - e.g.: Reference, photo, graph (Not more than 3 pages):