Guest Editorial

After thousands years evolution, aquatic animals are excellent swimmers and are able to perform intricate manoeuvres using flapping tails and fins. Studies from fish movements have inspired robotics researchers to develop biologically inspired robotic fish, which can propel and manoeuvre themselves like real fish. Robotic fish has many real-world applications, such as aquatic life observation, water quality monitoring, seabed exploration, search and rescue, and entertainment.

The development of biologically inspired robotic fish poses a number of technical challenges. In addition to the problems associated with underwater environments, such as uncertain water current, pressure and visibility, robotic fish must be designed to be operated in a 3D dynamic environment. We need to develop new methods for mimicking real fish movements, handling large variations in water pressure and current, waterproof of onboard electronics and computers, and detecting and recovering from unexpected errors. New capabilities arise frequently with the introduction of new sensors, actuators and computing hardware. The aim of this special issue is to gather important new theory, applications, metrics, models, surveys, and systems that provide innovative solutions to the challenging problems in the area of robotic fish, such as 1) Mechanisms & Mechatronics 2) Advanced Modelling & Techniques 3) Experiments & Applications.

There are seven papers in this special issue. The first paper "Learning From Fish: Kinematics and Experimental Hydrodynamics for Roboticists" by Lauder and Madden is a survey paper which outlines 16 results from recent experimental research on the mechanics, kinematics, fluid dynamics, and control of fish locomotion that summarize recent work on fish biomechanics. These findings have emerged from biomechanical studies of fish locomotion and provide important insights into the functional design of fishes. Some design features relevant to construction of robotic fish are suggested so that the high locomotion performance exhibited by fishes could be mimicked. In the second paper "Biologically Inspired Behaviour Design for Autonomous Robotic Fish" by Liu and Hu, some main design issues of the behaviour layer in a three-layered control architecture are investigated. Fuzzy logic control is adopted here to design individual robot behaviours. Simulation and real experiments are presented to show the feasibility and the performance of the designed robot. It is no doubt that this behaviour-based approach plays a key role for robotic fish to operate safely in unknown or dynamically changing environments.

The third paper "Locomotion and Depth Control of Robotic Fish with Modular Undulating Fins" by Low presents an environment-friendly robotic system that mimics undulating fins of real fish. A specially designed strip with a series of connecting linkages is constructed in a modular way. Each link is able to turn and slide with respect to adjacent links. Such a flexible structure could generate undulatory movements that enable a robotic fish to realise various swimming modes as a real fish does. In the forth paper "A New Type of Hybrid Fish-like Micro-robot" by Zhang, Guo and Asaka, a prototype of the robotic fish with a body, a pair of caudal fins, a base with legs and an array of artificial swim bladders are presented. Both caudal fins and legs are actuated by Ionic Conducting Polymer Film (ICPF) actuators. This hybrid fish-like micro-robot can swim and walk, which is required by many real-world applications.

The fifth paper "Bio-inspired Actuating System for Swimming Using Shape Memory Alloy Composites" by Tao, Liang and Taya addresses the design and construction of a caudal peduncle actuator to propel a robotic fish. The actuator is based on Ferromagnetic Shape Memory Alloy (FSMA) and hybrid mechanism, which is inspired by Scomber scombrus that utilises the thumniform swimming mode, i.e. the most efficient locomotion mode evolved in aquatic environment. It can provide critical driving thrust by using super elastic characteristics of SMA. Zhang *et al.* present a numerical analysis of an undulatory mechanical fin driven by Shape Memory Alloy (SMA) in the sixth paper. The fluid dynamics of force production associated with the undulatory mechanical fin is computed by Computational Fluid Dynamics (CFD) technique. It is concluded that undulatory amplitude, frequency and wavelength have significant effect on thrust generation in a certain range. The change in wavelength has the strongest influence on thrust generation, since it changes the propulsion model. In the seventh paper

"Development of ICPF Actuated Underwater Microrobots" by Ye *et al.*, a new prototype model of an underwater swimming micro-robot is proposed to realise both swimming and walking movements. It utilises a single piece of ICPF as the servo actuator. Its motion mechanism is illustrated through theoretical analysis. Experimental results indicate that the crab-like underwater micro-robot can perform traverse and rotation movements through the collaboration of its multiple legs.

This special issue is dedicated to robotics researchers, practicing engineers, and R&D managers, who wish to enhance or broaden their knowledge and expertise on how to build a robotic fish to mimic real fish movements and excellent swimming capability.

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