Chapter 8
Novel Swimming Mechanism for a Robotic Fish

Sayyed Farideddin Masoomi
University of Canterbury, New Zealand

XiaoQi Chen
University of Canterbury, New Zealand

Stefanie Gutschmidt
University of Canterbury, New Zealand

Mathieu Sellier
University of Canterbury, New Zealand

ABSTRACT

Efficient cruising, maneuverability, and noiseless performance are the key factors that differentiate fish robots from other types of underwater robots. Accordingly, various types of fish-like robots have been developed such as RoboTuna and Boxybot. However, the existing fish robots are only capable of a specific swimming mode like cruising inspired by tuna or maneuvering inspired by labriforms. However, for accomplishing marine tasks, an underwater robot needs to be able to have different swimming modes. To address this problem, the Mechatronics Group at University of Canterbury is developing a fish robot with novel mechanical design. The novelty of the robot roots in its actuation system, which causes its efficient cruising and its high capabilities for unsteady motion like fast start and fast turning. In this chapter, the existing fish robots are introduced with respect to their mechanical design. Then the proposed design of the fish robot at University of Canterbury is described and compared with the existing fish robots.

1. INTRODUCTION

Recent advances in robotics have enabled underwater robots to replace humans in oceanic supervision, aquatic life-form observation, pollution search, undersea operation, military detection and so on (Junzhi, Min, Shuo, & Erkui, 2004). Accordingly, a number of underwater vehicles and robots such as Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs) have been developed so far (Griffiths & Edwards, 2003; Wernli, 2000; Williams, 2004).

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Among underwater vehicles, biomimetic swimming robots inspired by various types of fishes have shown superior performance over other types of underwater robots (Paulson, 2004). These fish-mimetic robots are highly efficient, manoeuvrable and noiseless in marine environment (Hu, Liu, Dukes, & Francis, 2006). For instance, the propulsion system for some fishes is up to 90 percent efficient, while a conventional screw propeller has an efficiency of 40 to 50 percent (Yu & Wang, 2005).

Fish robots could be defined as fish-like aquatic vehicles whose motion is generated through undulatory and/or oscillatory motion of either body or fins (Hu et al., 2006).

The first fish robot, RoboTuna, was built at MIT in 1994 (Triantafyllou & Triantafyllou, 1995). As its name indicates, RoboTuna was inspired by a bluefin tuna. Developing this robot was a successful project of mimicking a fish robot; although, it has several deficiencies like being carriage mounted and non-autonomous. Three years later, at Charles Stark Draper Laboratory, the Vorticity Control Unmanned Undersea Vehicle (VCUUV) was developed based on the RoboTuna with some improvement and more capabilities such as being autonomous, capable of avoiding obstacles and having up-down motion (Anderson & Chhabra, 2002; Liu & Hu, 2004). However, VCUUV is more appropriate for a specific mode of swimming mainly cruising.

Accordingly, a number of robotic fishes for different mode of swimming were developed like lamprey robots capable of backward swimming (Ayers, Wilbur, & Olcott, 2000), MARCO inspired by boxfish suitable for maneuvering (Kodati, Hinkle, & Deng, 2007) and so on. Yet the state of the art in robotic fish shows that the robots built so far cannot have excellent performance in several swimming modes. For instance, tuna-mimicking robots are good at cruising while boxfish-mimicking robots are more suitable for hovering and maneuvering.

To have a skilled robot for two modes of swimming, the Mechatronics Group at University of Canterbury is developing a fish robot with novel mechanical design and control system. The novelty of the robot roots in its actuation system and causes its efficient cruising and its high capabilities for unsteady motion like fast start and fast turning. In the following chapter, the proposed mechanical design of the robot is introduced and discussed with respect to state of the art in the robotic fish.

The structure of the chapter is as follows. Section 2 introduces two main fish swimming categories and their subcategories. In this section, the state of the art in robotic fish is presented with respect to their swimming mechanisms. Section 3 discusses the capabilities and deficiencies of previously developed fish robots with respect to three main aspect of their mechanical design. Section 4 introduces the robotic fish designed at University of Canterbury. Section 5 concludes the chapter by comparing the mechanical design introduced in section 4 and fish robots developed by other institutes and universities.

2. LITERATURE REVIEW

Fish robots generally do not mimic the same fish motion in nature and, hence, have different swimming mechanisms. The main element which distinguishes fish robots from other types of underwater vehicles is their propulsion system. Fishes propel through undulation or oscillation of different parts of their body or fins called propulsors. When a fish passes a propulsive wave by its body or its fins in the opposite direction of its movement at a faster speed than swimming speed, its swimming method is referred to as undulation. On the other hand, in oscillation mode, fish generates propulsive waves by oscillating a certain part of its body around its base (Sfakiotakis, Lane, & Davies, 1999). Figure 1 presents some basic terminologies used in this chapter.

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