A Biomimetic, Swimming Soft Robot Inspired by the *Octopus Vulgaris*

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Abstract. This paper describes a first prototype of a cephalopod-like biomimetic aquatic robot. The robot replicates the ability of cephalopods to travel in the aquatic environment by means of pulsed jet propulsion. A number of authors have already experimented with pulsed jet thrusting devices in the form of traditional piston-cylinder chambers and oscillating diaphragms. However, in this work the focus is placed in designing a faithful biomimesis of the structural and functional components of the *Octopus vulgaris*, hence the robot is shaped as an exact copy of an octopus and is composed, to a major extent, of soft materials. In addition, the propelling mechanism is driven by a compression/expansion cycle analogous to that found in cephalopods. This work offers a hands-on experience of the swimming biomechanics of chephalopods and an insight into a yet unexplored new mode of aquatic propulsion.

Keywords: Soft robots, biomimetic propulsion, biomechanics.

1 Introduction

Lately, cephalopod-inspired pulsed-jet propulsion has been suggested as an alternative to the existing traditional and bioinspired ways of aquatic locomotion [1]. Cephalopods travel in water via a repetition of discontinuous jet pulses [2]. It is demonstrated [1] that this pulsed-jet propulsion offers significant benefits when compared against a continuous jet, like the one produced by a traditional propeller. A few pulsed-jet propelled underwater vehicles have recently been presented (i.e.[4,3,5]), however the present work focuses on the development of a completely new type of UUV which faithfully draws inspiration from the swimming technique adopted by cephalopods. The robot presented herein (Fig. 1) is unique in that it tightly matches the shape of a real octopus, it is made of flexible material and it employs an efficient propulsion mechanism which is very closely reminiscent of that one of cephalopods.

2 Biomimetic Soft Vortex Thruster

A polyurethane mould of an actual octopus was produced so that an exact copy of an original specimen could be obtained by filling the polyurethane mould

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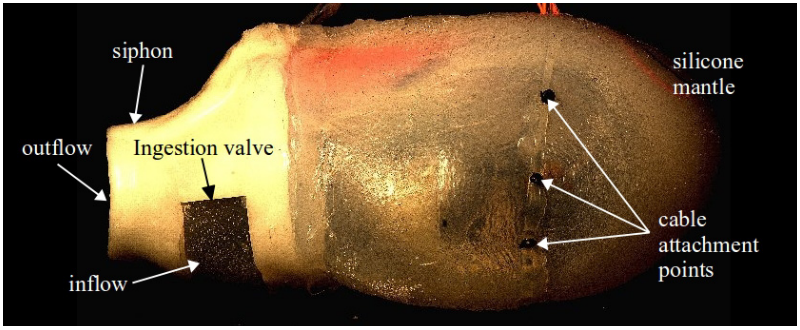

Fig. 1. Side view of the octopus-inspired prototype

with silicone. The silicone octopus mantle achieved in this way (see Fig. 1) was endowed with a cable driven actuation which drives the inward compression of the cavity and hence the expulsion of the internal fluid. Once the cables are released, the expansion of the mantle cavity is driven by the stresses generated within the silicone walls. This inflation of the chamber generates a sufficient negative pressure for ambient water to be sucked from outside through an orifice and, in this way, refill the mantle cavity. The repetition of these two phases allows the robot to effectively travel in water according to a propulsion routine which closely resembles the one of a swimming cephalopod.

After assemblage, the robot comprises of the silicone mantle, a nozzle, an inflow valve (Fig. 1) and the internal actuator and is supplied by two ion-lithium batteries which are immersed in the thicker layer of silicone of the upper portion of the mantle.

3 Results

One set of preliminary tests has been performed in water in order to roughly assess the swimming performances of this first prototype. The tentative analysis of this prototype seems to suggest that the implementation of a soft, collapsible syphon could aid in increasing the jetting performances of the robot. In addition, a more efficient pulsation cycle should entail low frequencies and an impulsive mantle contraction.

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