Soft Robotic Jellyfish Steering Control

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ABSTRACT

The exploration and ability to monitor vulnerable sponge and coral ecosystems can benefit from highly maneuverable underwater vehicles able to navigate and hover in cluttered spaces. Using soft materials for robots is safer than conventional robots as it reduces impact forces, allowing preservation these delicate environments.

The research hypothesis was that actuation of tentacles on one side of the jellyfish would impact the direction the robot travels to impart an ability to steer. Different amplitudes and offset pump actuations were visually tested until a consistent method of steering was found. A controlled descent was achieved by partially actuating one half of the robot, reducing its resistance to sinking. This created an angled descent which could be used to control the direction the robot travels.

Keywords

Soft Robotics, bio-inspired robots, coral reef, ocean monitoring, underwater vehicles

1. INTRODUCTION

The exploration and ability to monitor vulnerable sponge and coral ecosystems can benefit from highly maneuverable underwater vehicles able to navigate and hover in cluttered spaces. This propulsion and control technology, however, is poorly developed currently. Conventional robots are rigid, whereas the newer soft robots have the ability to elastically deform adapting to their environment in a non-invasive manner [1]. Using soft material for robots is much safer allowing stress to be distributed over a larger volume as well as increasing contact time reducing impact forces that could damage the robot or its environment [2]. Bio-inspired flexible propulsors have the potential to catalyze novel technology and the development of novel research vessels used in the exploration of these complex environments [3-15]. The cutting edge soft robotic jellyfish (Figure 2) will enable breakthrough research in vulnerable coral and sponge ecosystems.

Currently the soft robotic jellyfish contains two degrees of freedom with the ability to move upward or sideways through a series of tentacle actuations (Fig. 2) or downward through allowing the tentacles to return to their natural position and allowing its negative buoyancy to take effect. The purpose of the research presented in this paper was to develop a process which would enable a steering control in the previously developed soft robotic jellyfish. Through the use of the two impeller pumps which each control one half of the jellyfish's tentacles, it is hypothesized that a combination of offset pump efforts would enable steering control. Developing this steering ability in the soft robotic jellyfish would highly increase its future use in health monitoring of delicate ecosystems.

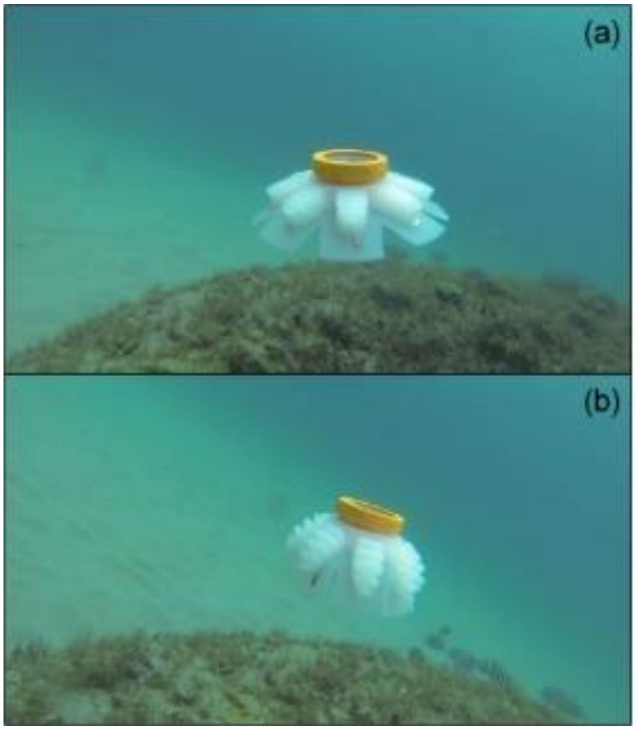

Figure 1: The soft robotic jellyfish during open water testing

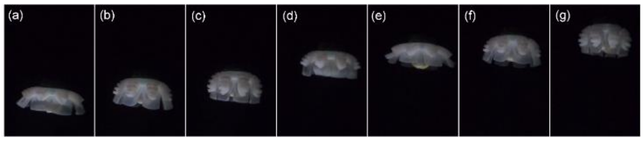

Figure 2: Photo sequence of the soft robotic jellyfish

2. METHODOLOGY

To begin, the jellyfish was tested to ensure it was swimming properly in a completely vertical direction to avoid skewed results due to unbalanced swimming. This was achieved by adding small washers to the top of the jellyfish's electronics can using an adhesive to ensure a proper balance as well as buoyancy. Each time the jellyfish was removed from the water, the following testing also included a re-check of the balance and buoyancy, as well as squeezing out any air bubbles that were introduced into the tentacles of the jellyfish, which could affect the trial's performance.

To implement steering control, various combinations of off-set pump actuations were visually tested for steering, two cycles of each combination can be seen in Fig. 3. All five of these pump effort combinations were also tested at two frequencies, 0.8 Hz and 0.3 Hz. In Fig. 4 the 0.8 Hz timing is shown.

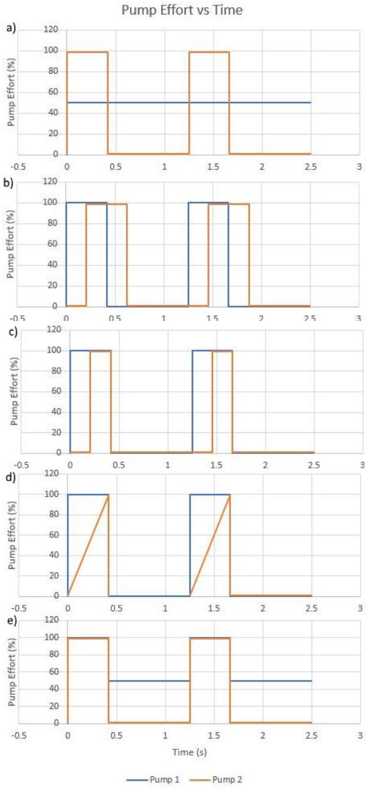

Figure 3: Variations of off-set pump actuations tested

These tests were performed in an aquarium tanks measuring 762mm long by 305mm wide by 320mm tall. The objective was to successfully swim from one side to the other lengthwise consistently. During testing, the jellyfish was programmed to perform 10 actuation cycles of each pump effort combination from Fig. 3, at which point another 10 cycles was performed with the pump efforts reversed to ensure the jellyfish was capable of being steered in both directions.

3. RESULTS

After testing each of the pump effort combinations at 0.8 Hz, it became visually clear that at 0.8 Hz there was not enough time between actuation cycles to consistently achieve the needed angle which would allow an angled propulsion of the jellyfish. At this point, a 0.3 Hz swimming frequency was introduced, which did allow enough time between actuation cycles to obtain a consistent angle needed for an angled propulsion.

The most consistent steering control was a result of using the pump effort combination seen in Fig. 3e at 0.3 Hz. This form of pump actuation allowed the jellyfish to swim upwards, and when pump 1 remained partially inflated it created an angled descent. This occurred due to there being a decreased resistance to sinking on one half of the tentacles. After sinking at an angle for just over 2 seconds, another actuation cycle would begin which allowed an angled propulsion. This sequence can be seen below in Fig. 4.

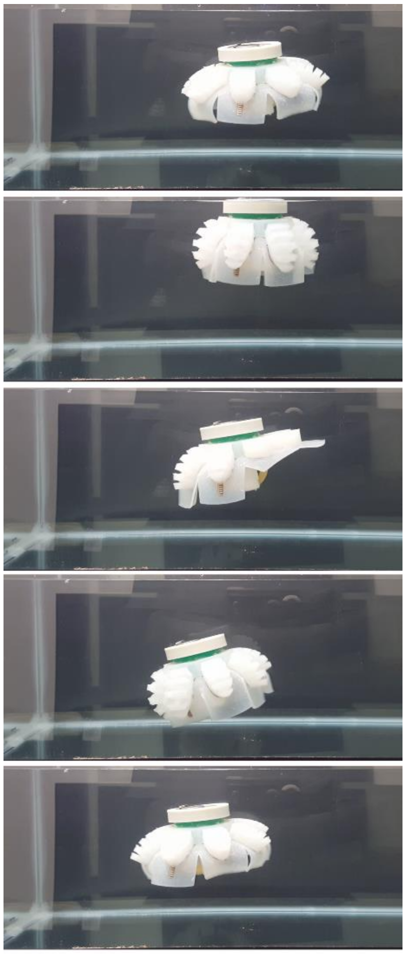

Figure 4: Angled descent followed by angled propulsion

4. CONCLUSION

In conclusion, it was possible to develop steering control for the soft robotic jellyfish. This was achieved using offset pump actuation cycles which left one half of the jellyfish partially inflated, creating an angled descent followed by an angled propulsion. This development has the potential to vastly increase the usability of the jellyfish during navigation of complex and delicate ecosystems for health monitoring.

5. REFERENCES

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