Identification of Objects with Passively Sensing Artificial Seaweed

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Magellan Research Grant

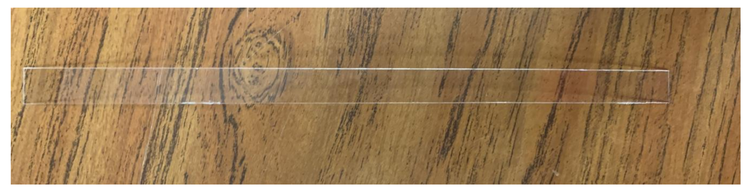
Introduction

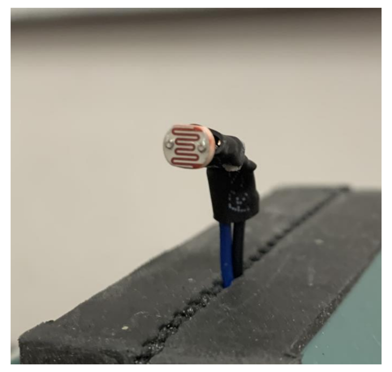
The project "Identification of objects with passively sensing artificial seaweed" has been a research project that has shown me the perils and triumphs that come with the research project. This project sought to create a flexible underwater sensor that I could test and characterize with static, dynamic, and hysteresis tests. Although this project aimed to create and characterize just one sensor, this project will lay the groundwork for an array of these sensors which can work together to detect and interpret underwater objects, like schools of fish and submersible vehicles. What makes this sensor unique is that common underwater sensing methods, like sonar, emit energy and can be detected. This sensor and the aforementioned array of sensors can be used wherever underwater sensing is needed, in fields spanning from biological research to defense.

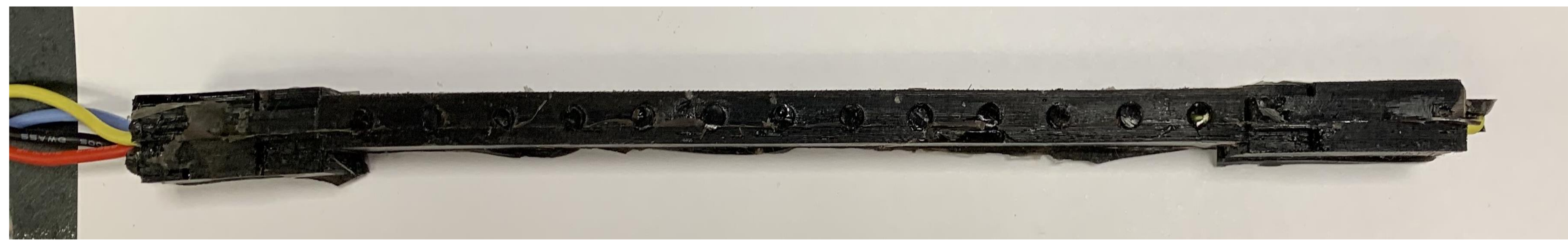
Fabrication Method

This sensor was created in a multi-step process:

1. 3D model and 3D print endcaps to encase the electrical components
2. Solder the LED and LDR electrical components
3. Place components in endcaps and seal
4. Join each endcap to the waveguide
5. Prepare a mold for the black panther polymer
6. Situate the waveguide and endcaps in mold
7. Mix black panther in equal parts
8. Pour black panther into mold
9. Wait for polymer to cure
10. Remove sensor from mold
11. Trim sensor of excess black panther







Acknowledgements

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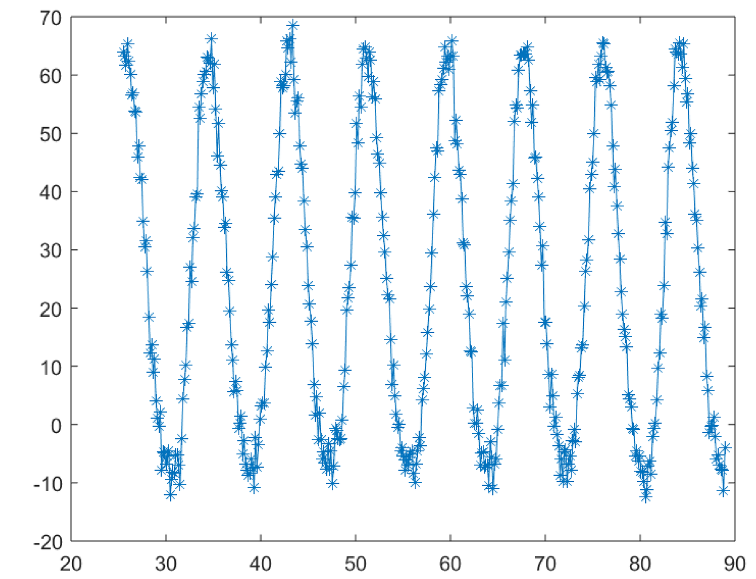
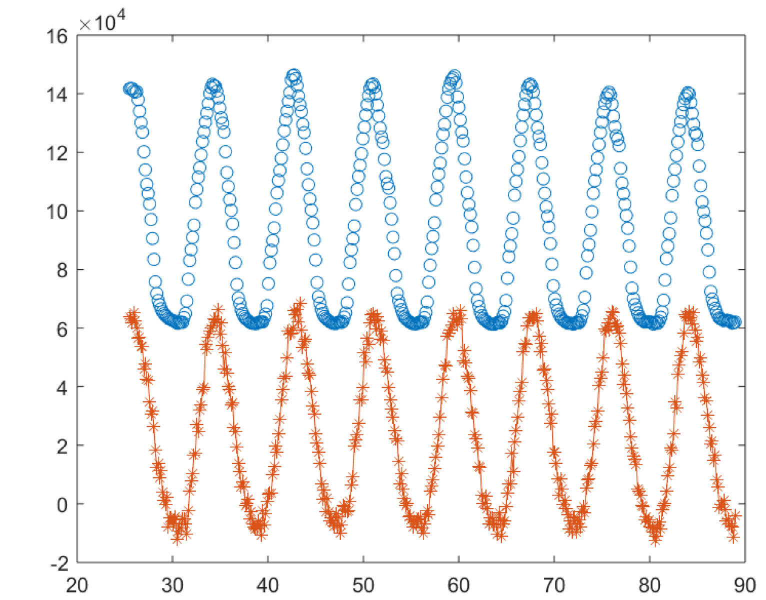
Working Principal

The LED in the sensor emits light at an intensity, measured in lumens. The light travels through the waveguide in the sensor and contacts the photo diode, or LDR, and the LDR outputs a resistance value based on the intensity of the light that contacts its interface.

When the sensor, and thus the wave guide internally, bend, light emitted from the LED leaks out from the waveguide and is lost. As a result, the intensity of light that interacts with the LDR interface is lesser when the sensor bends that if the sensor were to be straight. The sharper the bend, the less light that reaches the LDR and the higher the resistance that is output by the LDR.



Displacement of the sensor (Y-axis in mm) with respect to elapsed time (seconds)



Displacement and Resistance graphed on the same graph. This was used to determine the DAQ system and filters were running on the same time with no lag in the system.

Conclusion

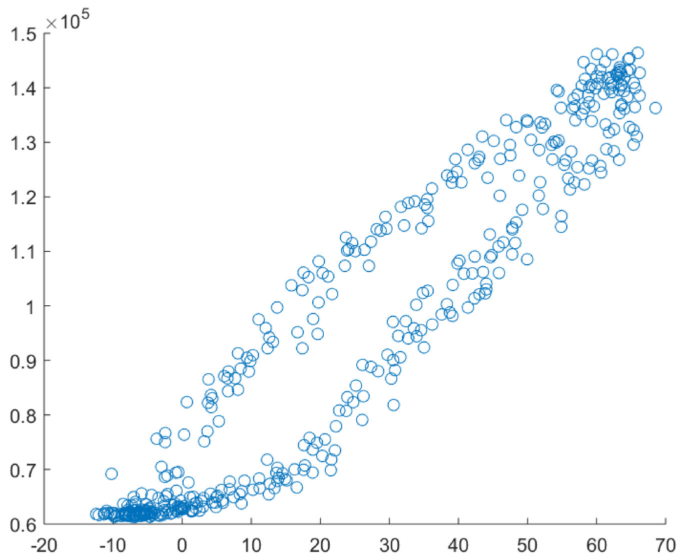
This project is not yet finished in its totality, and it will be passed along to a PhD student to wrap up the dynamic tests of a new sensor and the image processing. Currently, a MATLAB code is written, and the wrap up work will include collecting videos of the sensor in the flume and then applying a MATLAB code to fit a polynomial curve to the image. The sensor's resistance will then be analyzed in correlation to the sensor's bend and water velocity so that a relationship between sensor bend, sensor resistance output, and fluid flow can be derived.

The static and hysteresis tests show that this sensor concept is viable and can work. Once all tests for a single sensor are exhausted, the next steps to take include creating an array of these sensors and then running underwater turbulence around the array to characterize the array.

Hysteresis Test

A hysteresis test is used to determine an object or material's suitability. In this case, a hysteresis test was performed to determine the sensor's behavior moving forward and backward.

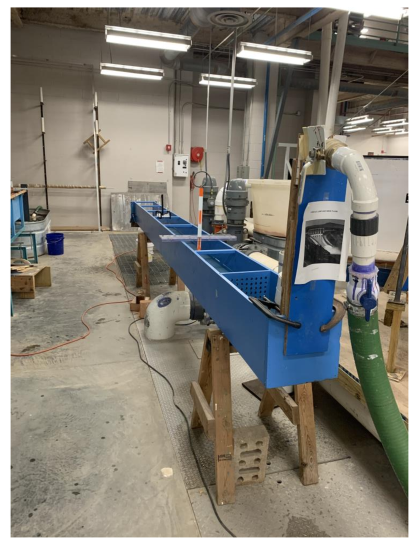
To perform this, the sensor was excited in one direction and then returned to its original position. The resulting hysteresis graph can be found here:

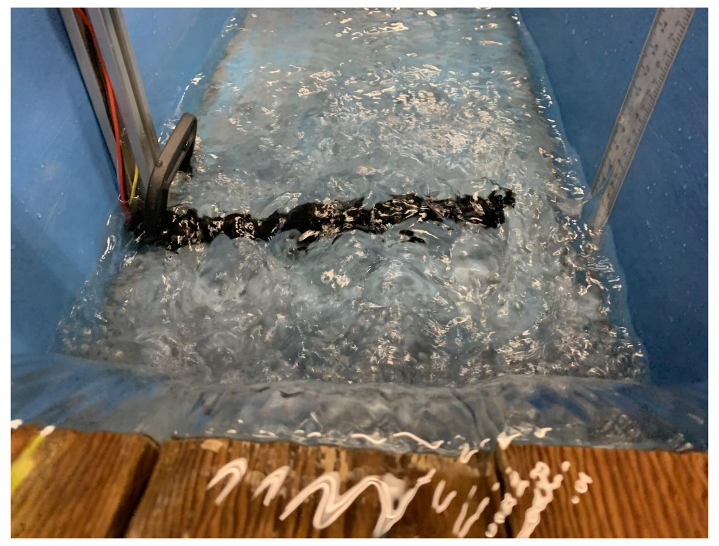


Hysteresis graph with Resistance (Ohms) on the Y-axis and Displacement (mm) on the X-axis

Dynamic Test

The sensor was secured in a flume used by the UofSC Civil Engineering Department and the sensor experienced three distinct flow rates. These flow rates were used to relate water turbulence and flow rate to the bend experienced by the sensor.





An image analysis was performed to fit curves to the sensor to characterize its bending angles. This step was interesting because unlike the static tests that were performed, the sensor did not uniformly bend at a given angle. There was geometric variability.