



Underwater Communications

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Abstract

By analyzing laser light propagation through water, we intend to further comprehend the communication techniques underwater. On naval platforms like submarines, underwater communication is essential to mission success; our purpose is to establish a bit error rate of laser propagation through a maritime environment to test how different factors affect underwater communication.

Background

In a study by Frank Hanson and Mark Lasher, the detrimental effects of water turbulence on laser propagation has been documented. It is known that certain factors affect underwater laser communication; therefore, having a method to calculate the bit error rate under specific stimuli would prove invaluable when studying the factors that affect effective transmission.

Images

Experimental setup of proof of concept:



This water tank is approximately 2 meters long and 15 centimeters in diameter. The receiver depicted at the end captures the information transmitted by the laser.



This image depicts the setup of the Helium-Neon laser shooting its beam through a rotor to manipulate the frequency with which we transmit data from the laser.

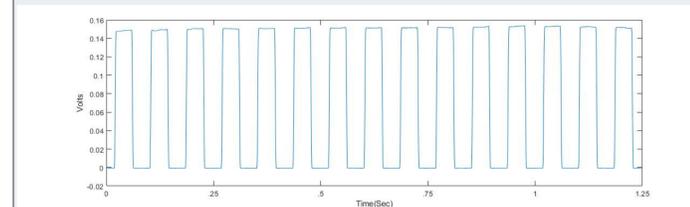
Methods

1. We set up the water tank with the laser communication apparatus that includes the bit rotor and the laser source at one end and on the other end was our data receiver. The data receiver measured the intensity of light hitting a plate and represented it as a voltage that could be read by a computer. The tank also had tubes and motors hooked up to it in order to induce a current in the water.
2. During the experiment a laser was shined through the the rotor, spinning at a known frequency of 120 Hz and through the water tank with different currents of water and then the beam intensity was read at the end of the tank.
3. In this experiment, the intensity of light that is read by the sensor is representative of how much data successfully manages to pass through the turbulent water.
4. Once the raw data is collected, MATLAB can be used to determine bit error rate by comparing how many bits were received under turbulent conditions as compared to a control of non-turbulent water.

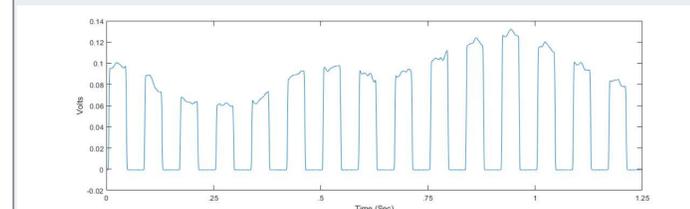
Results

The experiment tested 3 trials by shining the laser through calm water (Zero Volts), mild churning (Six Volts) and heavy churning (12 Volts). The results validate our expectation that increasing the churning rate would deplete the data received by the camera.

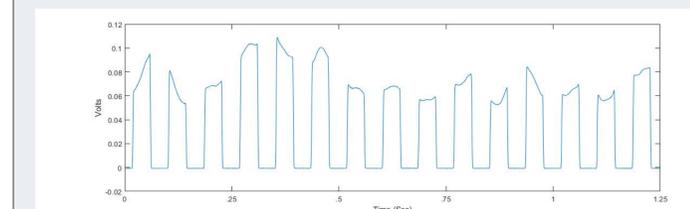
1. At the calm state (Zero Volts), almost all of the peaks maintain their integrity, which indicates a high retention of data. The reason for the peaks is the chopper blocking the beam, but the solid lines indicate that the calm water had little effect on the transmittance of data.



2. At higher rates of churning (Six Volts), less data was collected at the receiver as indicated below by the divots in the graph.



3. At the highest rate of churning (Twelve Volts), the least amount of data was obtained and collected at the receiver. The effect of the water on the beam can be identified by the increased divots seen below.



Conclusion

This experiment only simulates laser light passing through two meters of water which is not entirely realistic for naval applications; however, we are also using a much weaker laser source than would be used in real-world applications. Therefore we predict the results of this experiment to remain applicable to the Navy and future research.

For laser communications, the rate of data transfer is dependent on the sea state. The rougher the water is, the less effective laser communication is as a method for communication. As seen in the graphs, the increased water turbidity fosters lost volts seen in the volt threshold. Further work can be done to analyze how laser light can be altered to allow it to pass through water more efficiently.

References

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Acknowledgements

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