Clean Water in Port Report:
Dockside Particle Detector Environmental Analysis

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The Challenge

The Milwaukee Municipal Mooring Basin needs a way to be tested for pollution intrusion. This could be done by an easily transportable, fast, and low cost, hand-held particle detector designed at the University of Wisconsin – Milwaukee (UWM), but how effective is it?

Motivation

•*E. coli* specifically is a Fecal Indicator Bacteria (FIB) that can indicate a possible fecal contamination in beach water, tap water, swimming pools, etc.
•According to the EPA, the current quickest detection time for *E. coli* is 24 hours. [1]
•A few inexpensive techniques have been developed which include a “hand-held fluorescence detector”. [2] The other includes a technique that uses a special chemical solution that changes the color of the coliform *E. coli* in water, and uses a cellphone’s camera to record the color change. [3]
•Construct a device that utilizes Digital Inline Holographic Microscopic (DIHM) techniques.
•Through the development of a hand-held particle sensor, the final product will be able to detect pathogen concentrations and pollution surrogates in real time.

Methods

- Sample water from the Municipal Mooring Basin every 60 seconds for 75 minutes from the portside.
- Have a current meter measure the flow of water and its’ direction.
- Process the samples with the UWM Particle Sensor.
- Compare the results of the sensor with the results of numerous water quality tests, like pH, turbidity, etc.
- Report findings.

Components

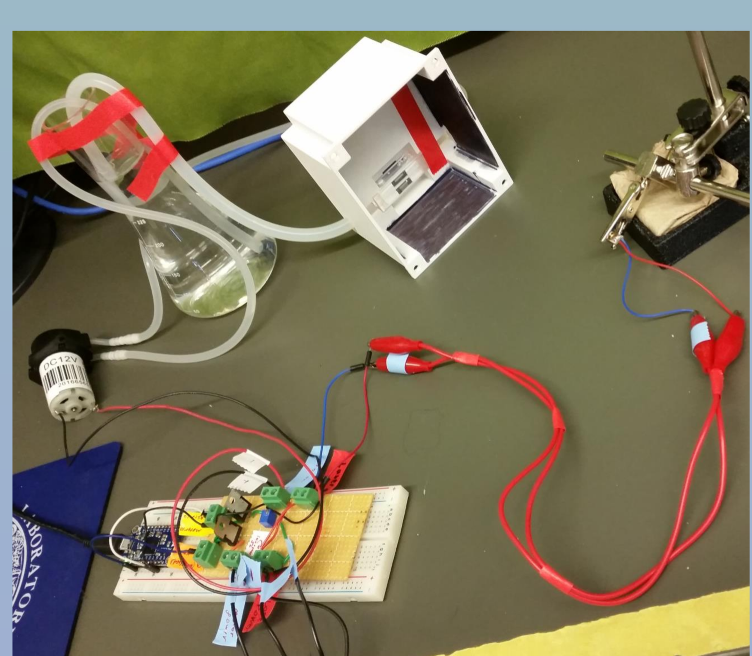


Figure 1: the Particle Detecting Apparatus

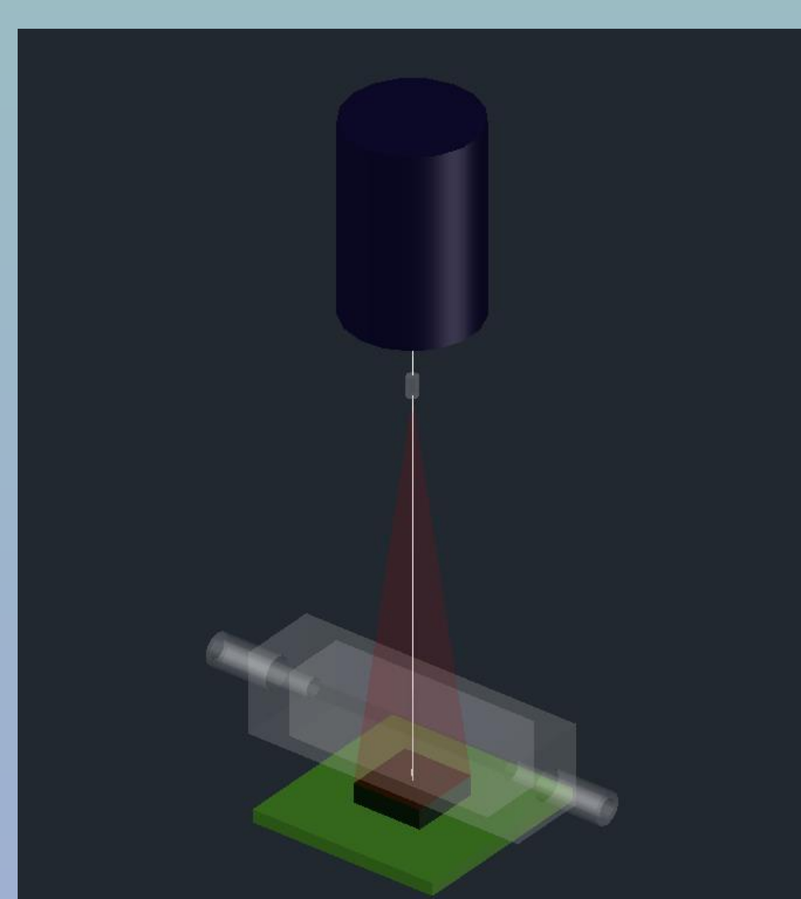


Figure 2: Basic visualization of the setup

Calculations

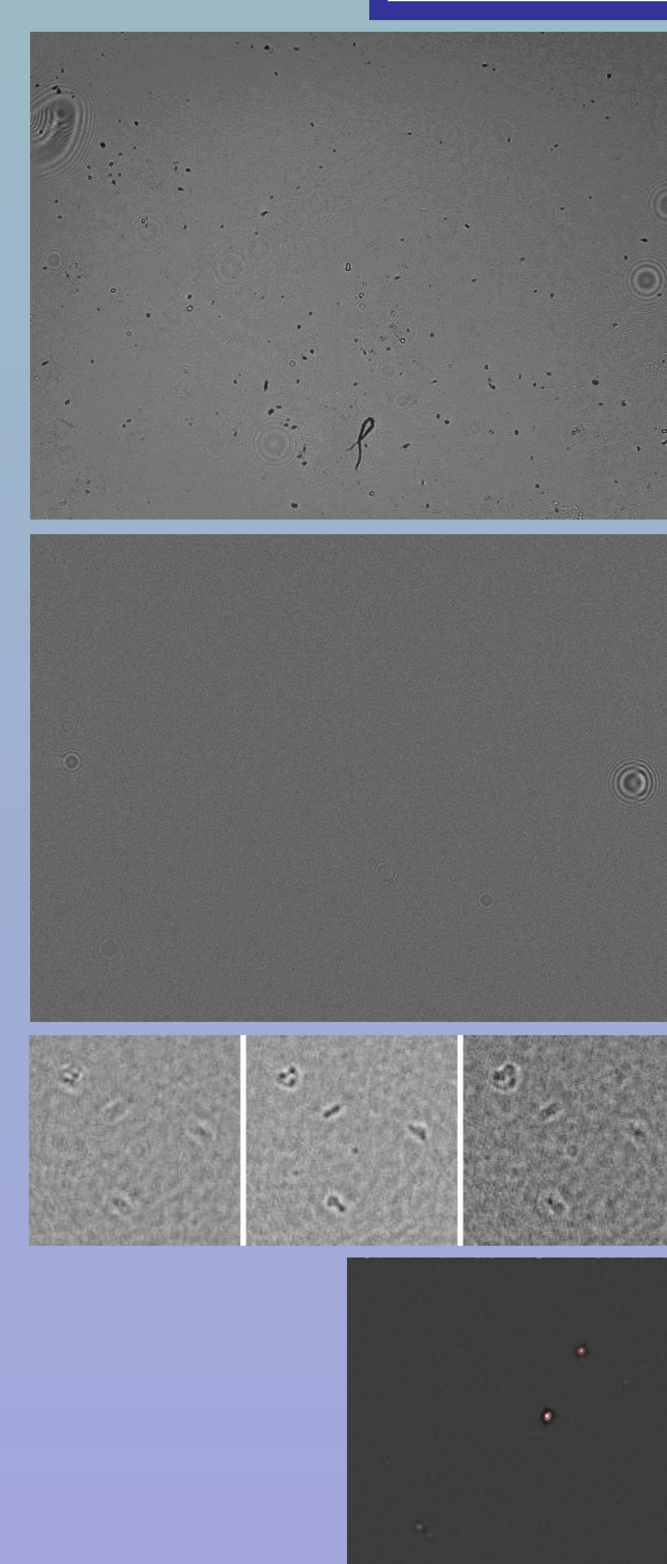
- GRIN Lens Working Distance is 1.411 mm
- Distance from focal point of light source to front of cuvette is 48.589 mm
- Distance from focal point of light source to back of cuvette is 61.089 mm
- Viewing area of cuvette by CMOS sensor is approx. 240 mm^3 = .24 ml
- Distance from focal point of the light source to CMOS sensor is 62.089 mm
- Wavelength of laser light source is 650 nm
- The Numerical Aperture is approx. .0344
- The lateral resolution is approx. 9.5 µm
- The depth resolution is approx. 274 µm

Pictures of Area

Figure 3: Bird’s eye view of School of Freshwater Sciences and the Milwaukee Municipal Mooring Basin. The blue circle is where water samples were taken. The red X is where the current meter was set up.

Figure 4: An area where yachts drift by juxtaposed by trash doing the same. A bottle of imported water, in this case.

Software Image Analysis



Raw Data Collection
(example *E. coli* in deionized water)

Filtered Image
(example *E. coli* in deionized water)

Different Depths
(A 2nd set of *E. coli* in deionized water at depths from the camera of 3.3 cm, 3.5 cm, & 3.7 cm respectively)

Blob Counting
(A 3rd set of *E. coli*)

Figure 5: Steps of Image Acquisition.

Data & Results

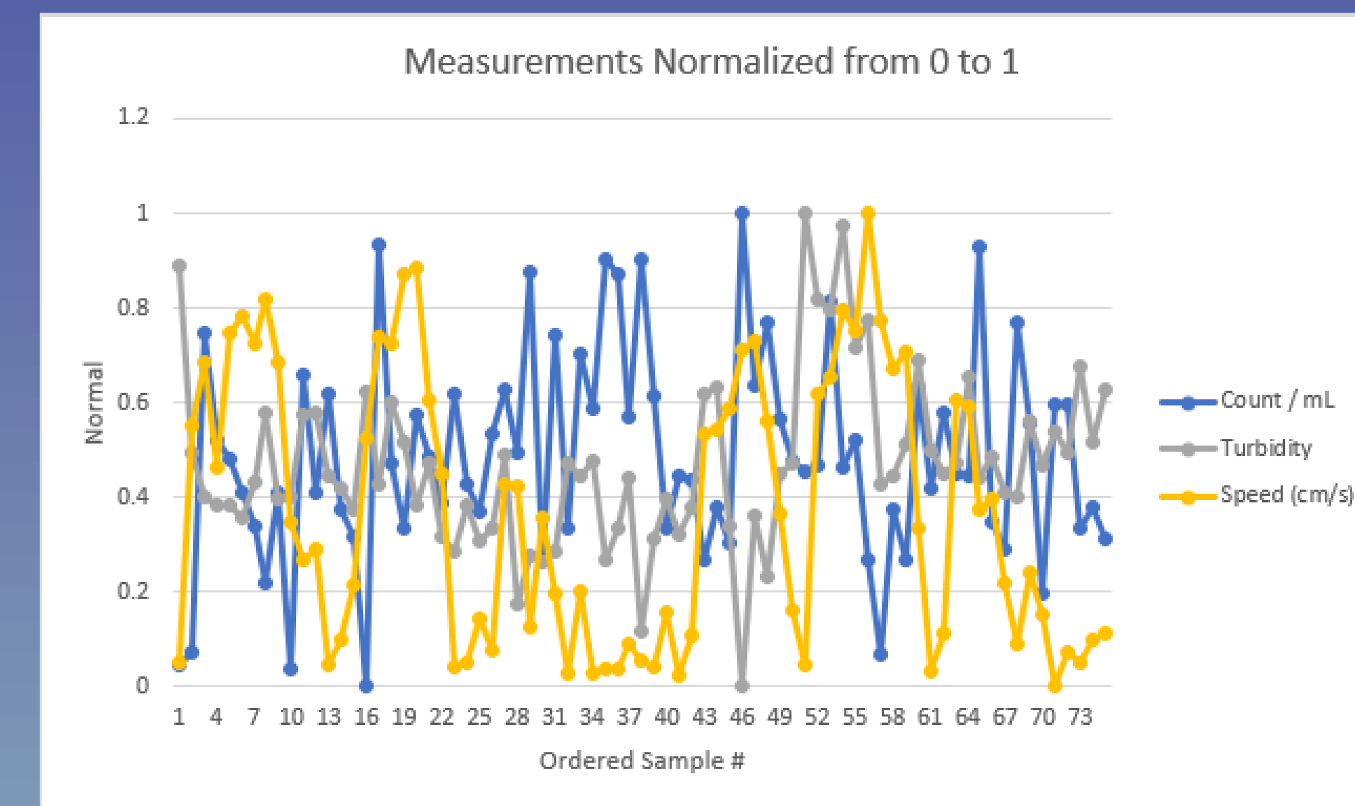


Figure 6: Graph depicting the various measures of water quality for all 75 samples.

Applications of the Technology

Due to the software making the sensor fast, reliable, and inexpensive, this technology can be applied to:
•Public beaches/parks
•Medical applications
•Water utility and wastewater treatment facilities
•Developing countries worldwide

Future Work

Currently, the sensor is being tested for its’ possible application in detecting COVID-19 in liquids, so future work in the area has been postponed in favor of trying to help save lives. Other than that, we plan on implementing faster processing of imaging, and detecting other viruses!

Acknowledgments

We thank: the Office of Undergraduate Research for funding our research, the Prototyping Club, James Van Eerden, and Dan Beller for providing their 3D printing equipment and expertise that helped us create our 3D prints. We thank Michael Ballo and Shawn Strong for their previous work on this project.

References

[1] Olstadt J, Schauer J J, Standridge J and Kluender S 2007 A comparison of ten USEPA approved total coliform/E. coli tests *Journal of Water and Health* **5** 267-82
[2] Wildeboer D, Amirat L, Price R G and Abuknesha R A 2010 Rapid detection of Escherichia coli in water using a hand-held fluresence detector *Kings College London* **44** 2621 – 8
[3] R Richard C 2013 Research team develops new method to detect E. coli in water – University of Alberta